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On a New Caryophyllaeid Cestode, *Adenoscolex oreini* gen. et. sp. nov. from Fresh-water Fish in Kashmir, and a Note on some Related Genera

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From the Department of Parasitology, London School of Hygiene and Tropical Medicine

A large number of caryophyllaeid worms was collected from the gut of *Oreinus sinuatus*, a common fresh-water fish in Kashmir, and sent to the writer by M. Mallik, Director, Department of Fisheries, Kashmir. These worms are described here as a new species for which a new genus is found to be necessary and the name *Adenoscolex oreini* n. g., n. sp. is proposed. The new genus falls in the sub-family Capingentinae Hunter, 1927.

Description

The body is elongated, somewhat dorsoventrally flattened and elongated oval in cross-section. Fully mature worms are broader and thicker in the posterior seventh of the body length. The largest worm is 38 mm. long and nearly 2 mm. wide. The smallest specimen with testes and without eggs in the uterus measures 18 mm. in length and 1.3 mm. in width. Most of the worms are 30–35 mm. long and 1·45–1·75 mm. wide.

The scolex is smooth and undifferentiated from the remaining part of the body. It is slightly wider than the body width, measuring nearly 2 mm. in width and half as much in length. The anterior border is smooth and somewhat truncated. External frills, wrinkles, grooves or the so-called bothria are absent. The attachment to the gut epithelium of the host is apparently maintained only by the adhesive secretion of the gland cells which show an extensive development in the scolex, and are extended posteriorly in the form of three well developed columns for more than three-quarters of the anterior body length. In the neck region of the mounted specimens these

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glandular columns can be seen even by the naked eye. In a cross-section of the body behind the neck region these glandular elements are seen in three groups in the medullary parenchyma (Figs. 1, 4–7 and 10). The musculature of the scolex does not show any special development. The scolex is followed by a short neck which is slightly narrower and measures 1·3–1·7 mm. in width and about the same or slightly less in length. The remaining width of the body is more or less constant except in the region of the uterus and the ovary where it is slightly wider in fully mature worms. The body behind the ovary narrows abruptly to form a blunt posterior end.

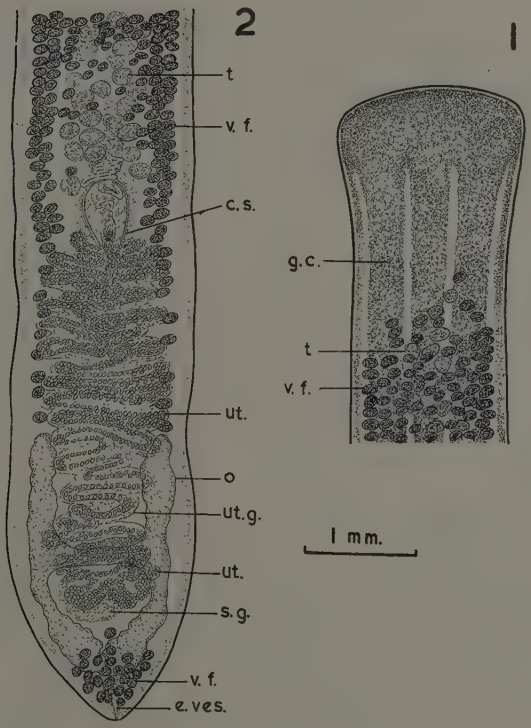
The excretory pore is terminal and leads into the excretory vesicle, 0·225 mm. long and 0·015–0·025 mm. wide at the base. Fourteen to eighteen excretory vessels are seen in the cortical parenchyma of the body when examined in cross-section.

The body musculature is not well developed. The outer longitudinal muscle layer near the sub-cuticular nuclear layer is very poorly differentiated. The inner longitudinal muscle layer, dividing the body parenchyma into the cortical and medullary regions, consists of very small and narrow groups of muscle fibres. A few transverse and dorso-ventral fibres are also present in the cortical and medullary parenchyma.

The posterior seventh of the body length is occupied by the cirrus sac, uterus, ovary and the post-ovarian vitelline follicles. In a worm 35 mm. long, 5 mm. are occupied by this region. The uterus occupies the major part of this region, viz., 3–3·75 mm. The vitelline follicles and the testes commence almost at the same level, immediately behind the neck. The first few solitary follicles which commence 1–1·8 mm. from the anterior extremity are immediately followed by closely aggregated vitellaria surrounding the testes.

The testes are rounded or broadly oval, and larger than the vitelline follicles, measuring 0·18–0·23 × 0·15–0·18 mm. They are located in the medullary parenchyma and spread over the anterior 6/7 of the body length. They are not clearly seen in the whole mounts being thickly crowded by the surrounding vitelline follicles except in the region of the vas deferens and cirrus sac. The arrangement and number of the testes is variable at different levels of the body. In a cross-section 5–6 testes are seen arranged in 2–3 rows. The vas deferens is strongly coiled and spread over a length of 0·75 mm. in front of the cirrus sac. The outer seminal vesicle is

apparently absent. The cirrus sac has a separate opening which does not join the utero-vaginal canal. A genital atrium is also absent. The cirrus sac measures 0·4–0·575 × 0·325–0·375 mm. and inner seminal vesicle 0·225 × 0·075 mm.



Adenoscolex oreini gen. et sp. nov.

Fig. 1.—Anterior end. Fig. 2.—Posterior region of mounted specimen.

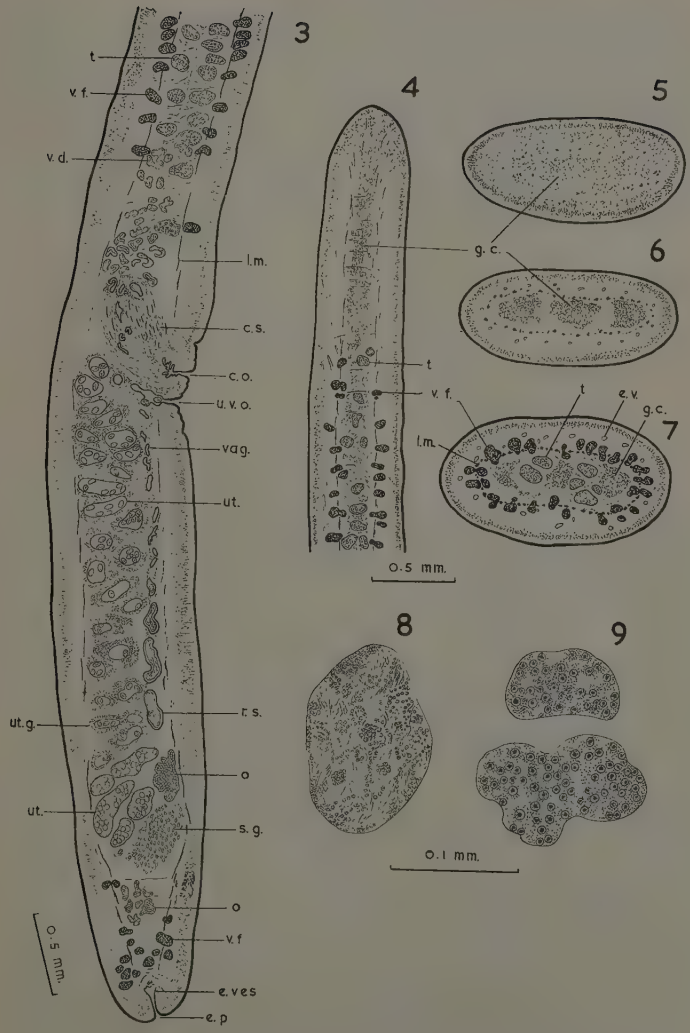
Abbreviations used in Figs. 1 to 17.

c.o.=cirrus opening; **c.s.**=cirrus sac; **e.p.**=excretory pore; **e.v.**=excretory vessel; **e.ves.**=excretory vesicle; **g.c.**=gland cells; **l.m.**=inner longitudinal muscle layer; **o.**=ovary; **o.i.**=ovarian isthmus; **oot.**=oötype; **r.s.**=receptaculum seminis; **s.g.**=shell gland; **t.**=testis; **ut.**=uterus; **u.v.o.**=utero-vaginal opening; **ut.g.**=uterine glands; **vag.**=vagina; **v.d.**=vas deferens.

The vitelline follicles are mostly lateral in the region of the cirrus sac, and posterior to it they are arranged loosely in a single row on each side of the uterus, terminating in front of the anterior horns of the ovary. The vitelline follicles are absent in the region of the ovary. Posteriorly they form a small group of post-ovarian vitelline follicles, separated from the pre-ovarian vitelline follicles by the ovary. From the cross-sections and the sagittal sections of the worms, it is clear that the arrangement of the vitelline follicles in the body parenchyma is typical of the sub-family Capingentinae. They are placed at the level of the inner longitudinal muscle layer and extend partly into the cortical and partly into the medullary parenchyma. Thus the vitellaria hold an intermediate position between the cortical and the medullary parenchyma. A few follicles may also be present slightly outside or inside this level. The follicles are somewhat irregular in shape and show invariably a dumb-bell shaped outline in the cross-section, being thinnest where they are squeezed between the inner longitudinal muscle layer. Circular and oval types of follicles are also present. While retaining this position, the vitellaria surround the testes completely and form a definite layer. They are always smaller than the testes and measure 0·105–0·180 × 0·075–0·090 mm. or 0·090–0·105 mm. in diameter. The post-ovarian vitelline follicles partly overlap the posterior horns of the ovary. Their number and posterior extent is variable. They terminate 0·08–0·23 mm. from the posterior extremity.

The ovary has the outline of an inverted "A". The lower horns or wings are consistently bent inwards so that they appear to meet. Since these lower horns never fuse with each other, the ovary may be said to have the basic "H" shape with strongly bent lower horns. The ovarian isthmus or the commissure is more or less at the middle of the ovary. The lower horns are narrow near the isthmus but they soon become fairly broad and slightly lobed at the ends. Both the isthmus and the ovarian wings are entirely in the medullary parenchyma. The wings reach to within 0·5–0·6 mm. of the posterior tip and measure 1·9–2·2 mm. in length and 0·25–0·37 mm. in width.

The uterus is very well developed. It is compactly coiled behind the ovarian isthmus where it has few or no uterine gland cells surrounding it, but in front of the isthmus and onwards they are thickly surrounded by these glands and form symmetrical transverse coils followed by closely set coils. These never extend beyond the cirrus sac. The shell gland is very well developed and located behind the



Adenoscolex oreini gen. et sp. nov.

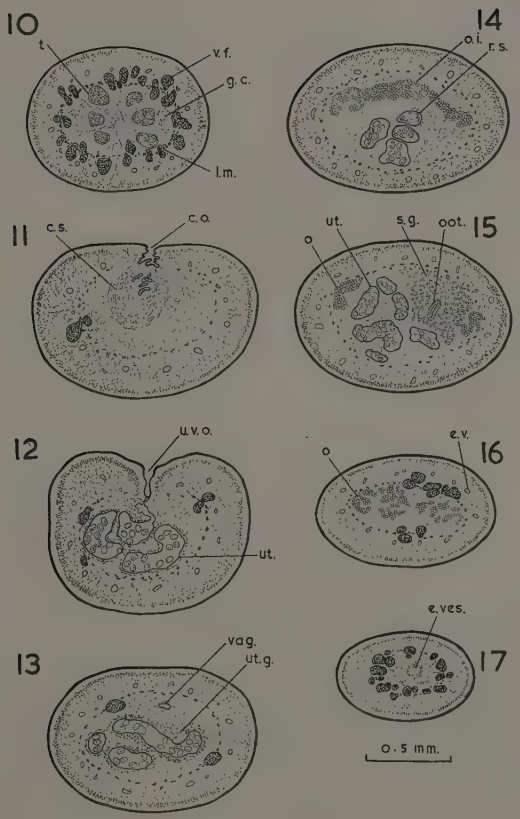
Fig. 3.—Sagittal section of posterior region. Fig. 4.—Sagittal section of anterior end. Fig. 5.—Cross-section of scolex. Fig. 6.—Cross-section of neck. Fig. 7.—Cross-section of body behind neck. Fig. 8.—Testis. Fig. 9.—Vitelline follicles in cross-section.

isthmus and nearer the right lower horn of the ovary, measuring 0·4–0·45 × 0·3 mm. The receptaculum seminis is also well developed and is extended slightly anterior to the ovarian isthmus, measuring about 1 mm. The vagina runs more or less a straight course for slightly more than 1 mm. and joins the terminal end of the uterus to form the utero-vaginal canal, about 0·17–0·18 mm. long. The utero-vaginal opening is located 0·15–0·16 mm. behind the cirrus opening. A common genital atrium is absent and the male and female openings are distinctly separate on the ventral surface.

The eggs are ovoid and operculated with a small blunt protuberance near the basal end. The mature eggs measure 64–75 × 36–48 μ.

Systematic Position

Hunter (1927a) proposed the genus *Capingens* for the species *C. singularis*, from the stomach of *Carpiodes carpio* in Minnesota, and placed it along with two other genera, *Lytocestus* Cohn, 1908 and *Monobothrioides* Fuhrmann and Baer, 1925, in a separate sub-family Lytocestinae, characterized by the presence of inner longitudinal muscles internal to the vitellaria, annularly arranged about the muscles in the cortical parenchyma. The vitellaria in *Capingens* were described as having their origin within the medullary parenchyma and extending into the cortical parenchyma past the inner longitudinal muscles, which did not hold true for the other two genera. Hunter (1929) described two more genera, *Pseudolytocestus* and *Spartoides* for the species *P. differtus* and *S. wardi*, the former from the intestine of *Ictiobus bubalus* in Mississippi and the latter from *Carpiodes carpio* in Illinois and *Carpiodes thompsoni* and *Ictiobus cyprinella* in Minnesota. Both the genera were described as having the same location of the vitellaria in relation to the inner longitudinal muscles as in *Capingens*. This constant difference in the said three genera from the remaining genera of Lytocestinae caused Hunter to place them in a separate sub-family Pseudolytocestinae with *Capingens* as the type genus. Hunter (1927b) published a monograph on the Caryophyllaeidae of North America (distributed in 1930) in which he changed the name of the sub-family Pseudolytocestinae to Capingentinae, giving preference to the latter name after the type genus. He thus classified the family Caryophyllaeidae Leuckart, 1878 into four sub-families, brief characters of which are given below :



Adenoscolex oreini gen. et sp. nov.

Fig. 10.—Cross-section, middle of the body. Fig. 11.—Cross-section at the level of cirrus opening. Fig. 12.—Cross-section at the level of the opening of utero-vaginal canal. Fig. 13.—Cross-section at the level of uterus. Fig. 14.—Cross-section at the level of ovarian isthmus. Fig. 15.—Cross-section, behind ovarian isthmus. Fig. 16.—Cross-section at the level of the bent posterior horns of ovary. Fig. 17.—Cross-section posterior end, at the level of excretory vesicle.

Caryophyllaeinae (Nybelin, 1922) char. emend. Hunter, 1927.

Inner longitudinal muscles always surrounding the vitellaria which are medullary and annularly arranged. Uterine glands present. Sexual apertures and ovary within last quarter of body length.

Capingentinae Hunter, 1927.

Inner longitudinal muscles *partly internal* to vitellaria which arise in medullary parenchyma and extend for one third to one half their length past the inner longitudinal muscles into the cortical parenchyma where they are annularly arranged. Uterine glands present. Sexual apertures and ovary in last fifth of body.

Lytocestinae Hunter, 1927.

Inner longitudinal muscles *entirely* internal to vitellaria which are annularly arranged in cortical parenchyma. Uterine glands present. Sexual apertures and ovary in the last quarter of body.

Wenyoninae Hunter, 1927.

Longitudinal muscles either in one thick layer occupying entire cortex or split into two layers. Vitellaria in two lateral rows in medullary parenchyma. Uterine glands absent. Sexual apertures in anterior half and ovary in posterior half of body.

According to this classification the present form belongs to the sub-family Capingentinae because of the similar location of the vitellaria in relation to the inner longitudinal muscle layer.

(Wardle and McLeod, 1951, have raised the family Caryophyllaeidae to the rank of a new order Caryophyllidea and the four sub-families to the rank of families.)

Discussion

Of the three existing genera in the sub-family Capingentinae, the present form is closer to the genus *Pseudolytocestus* because in both the uterine coils do not extend beyond the cirrus sac and the scolex shows no specialization in the form of loculi or bothria. The scolex, however, is not entirely identical in the two forms. In *Pseudolytocestus* the scolex besides being smaller than the body width, has a conical base and a terminal introvert formed by the inner longitudinal muscles which are well developed and form a

continuous ring in the distal extremity of the organ. The longitudinal and the circular muscles of the cuticular system of the scolex are also prominent in this form. Contrary to this, the scolex of the present form is broader than the body width, the anterior border is more or less truncate, and the musculature is as poorly developed as in the remaining part of the body. The gland cells for the attachment of the scolex with the gut epithelium of the host, of which no mention is made in the description of the scolex of *Pseudolytocestus*, show an extensive development and present a prominent feature in the scolex of the present form. Three well developed columns of this tissue extend for more than three quarters of the anterior body length. The presence of post-ovarian vitelline follicles and inverted A-shaped ovary are further characters to differentiate the present form from *Pseudolytocestus*. Comparing further characters from the only existing species of *Pseudolytocestus*, *P. differtus*, the present form differs in having a much larger body size, well developed transversely arranged uterine coils, larger size of vitelline follicles, testes and eggs, and lastly the presence of a receptaculum seminis which is said to be absent in the former species. Of these differences, the presence of post-ovarian vitelline follicles, the shape of the ovary and the nature of scolex are sufficient characters in themselves to distinguish the present form as a separate genus from *Pseudolytocestus*.

The genus *Capingens* represented by *C. singularis*, has a well developed scolex with a pair of bothria occupying one quarter to one fifth of total body length, the uterine coils extend anterior to the cirrus sac and the pre-ovarian vitelline follicles are connected with the post-ovarian vitelline follicles by a lateral row. All these characters are in contrast to those in the present form. Similarly the presence of three pairs of loculi on the scolex, the opening of cirrus sac within the confines of the ovarian wings, the absence of post-ovarian vitelline follicles, U-shaped ovary and the development of uterine coils anterior to the cirrus sac in the genus *Spartoides* and its only species, *S. wardi*, distinguish it from the present form.

Considering these differences, it is clear that the existing three genera of the sub-family cannot contain the present species. The formation of a new genus is necessary for which the name *Adenoscolex* is proposed and it includes the new species *A. oreini*.

Adenoscolex gen. nov.

Generic diagnosis : Capingentinae. Scolex smooth and not clearly marked off from the rest of the body. Gland cells well developed in the scolex and continued in the body region. Cirrus sac and utero-vaginal canal open separately at the beginning of the posterior seventh of the body length. Ovary entirely in medullary parenchyma and its lower horns bent inwards to give the appearance of an inverted "A". Uterine coils extend beyond anterior horns of ovary but never anterior to cirrus sac. Receptaculum seminis well developed. Vitelline follicles partly cortical and partly medullary, being mostly located at the level of inner longitudinal muscle layer. Post-ovarian vitelline follicles present.

Parasites of fishes.

Genotype : *Adenoscolex oreini* n. sp.

Adenoscolex oreini n. sp.

Specific diagnosis : With characters of genus. Adult parasites 30–35 mm. or more in length and 1·45–1·75 mm. in width. Scolex smooth, with anterior truncated margin and slightly wider than body width. Well developed gland cells in the scolex extended to more than three quarters of anterior body length. Musculature poorly developed in scolex and body. Neck 1·3–1·7 mm. long and about the same width. Vitellaria and testes commence immediately behind neck. Testes larger than vitelline follicles, 0·18–0·23 × 0·15–0·18 mm. in size. Cirrus sac 0·4–0·6 × 0·35 mm. in size and its opening located at the beginning of posterior seventh of body length, 0·15–0·16 mm. anterior to female opening. Vitelline follicles mostly dumb-bell shaped in cross-section ; oval and rounded follicles also present, with an average size of 0·15 × 0·085 mm. or 0·1 mm. in diameter. Post-ovarian vitelline follicles never join pre-ovarian vitelline follicles ; former partly overlap posterior horns of ovary at the ends. Lower horns of ovary strongly bent inwards but their ends never fuse with each other. Ovarian wings about 2 mm. long and 0·3 mm. wide. Shell gland 0·4–0·45 × 0·3 mm. Seminal receptacle up to 1 mm. long and vagina slightly longer. Utero-vaginal canal 0·18 mm. long. Uterine gland cells well developed but absent in the region of the uterus behind ovarian isthmus. Uterus well developed and arranged in symmetrical transverse coils occupying 3–3·75 mm. of posterior seventh of body length. Eggs large, ovoid, 64–75 × 36–48 μ.

Host : *Oreinus sinuatus.*

Habitat : Intestine.

Locality : Anantnag, Kashmir (Arapat Stream).

Type : To be deposited in the Dept. of Parasitology, London School of Hygiene and Tropical Medicine, and paratypes in the Dept. of Zoology, S.P. College, Srinagar, Kashmir.

On some genera related to *Adenoscolex*

1. *Caryophyllaeides* Nybelin, 1922

The inverted A-shaped ovary of *Adenoscolex* recalls a similar shape of ovary in the genus *Caryophylaeides* of the subfamily Caryophyllaeinae. Besides the difference in the location of the vitellaria in relation to the inner longitudinal muscle layer, *Adenoscolex* differs from *Caryophyllaeides* in the following points :

1. Uterine coils never extend anterior to cirrus sac.

2. Cirrus sac does not open into utero-vaginal canal, the genital pores being distinctly separate on the ventral surface.

3. Cirrus sac does not open within the confines of the ovarian wings being located at a considerable distance anterior to the latter.

4. Although the ovary appears to be inverted A-shaped, its posterior horns never fuse at the ends.

Szidat (1941) suggested the relation between *Caryophyllaeides* and *Spartoides* Hunter, 1927, on the basis of the shape of the ovary. In the genus *Spartoides*, the ovary is U-shaped and the cirrus sac opens within the confines of its wings. In *Caryophyllaeides*, the ovary is inverted A-shaped and it is the presence of long anterior horns with cirrus sac in between them that presents the superficial resemblance. Basically the shape of the ovary of the two genera is not the same. Szidat also recorded vitelline follicles in the cortical parenchyma in *Caryophyllaeides*, and expressed his doubts on the validity of the present classification, which is based on the position of the vitellaria. It will, however, involve the re-examination of all the existing species of the family before Hunter's classification can be revised.

2. *Khawia* Hsü, 1935 and *Bothrioscolex* Szidat, 1937

Adenoscolex n.g. shows some superficial resemblance to the genera *Khawia* and *Bothrioscolex* of the subfamily Lytocestinae, mainly in the presence of post-ovarian vitelline follicles. From both these genera *Adenoscolex* differs in the position of the vitellaria, the shape of the ovary and the scolex, the position of the genital pores and the absence of a common genital atrium, the male and the female pores being distinctly separate on the ventral surface.

The species of *Khawia* and *Bothrioscolex* are so close to each other that there is hardly any justification for retaining them in separate genera. In fact, the same species, *Caryophyllaeus japonensis* Yamaguti, 1934, was claimed by both the authors, Hsü and Szidat, and placed in their respective genera.

The genus *Khawia* was first proposed by Hsü (1935) for the species *K. sinensis*, from the gut of a cyprinid fish, *Cyprinus carpio* in China. This species has a flat, fan-shaped scolex with frilled or wrinkled anterior margin. On the basis of the presence of the vitellaria in the cortical parenchyma, Hsü placed his genus in the subfamily Lytocestinae, and for similar reasons he transferred *Caryophyllaeus japonensis* from Caryophyllaeinae to this subfamily as a member species of his genus. Szidat (1937), unaware of the genus *Khawia*, proposed a new genus *Bothrioscolex*, in the subfamily Lytocestinae, and placed *C. japonensis* as the genotype. He also added three more species to *Bothrioscolex*, *B. prussicus*, *B. rossettensis* and *B. dubius*, recovered from the gut of *Carassius carassius* in East Prussia, Germany. Later in 1941, when he was aware of the genus *Khawia*, Szidat described *Khawia baltica* from the gut of *Tinca tinca* in East Prussia. The scolex of this species is said to resemble that of *K. sinensis*. Szidat preferred to retain the genus *Bothrioscolex* on the basis of the difference in the shape of its scolex from that of *Khawia*. The scolex of *Bothrioscolex* is said to be clearly marked off from the remainder of the body, being spherical, cone-shaped with an anterior pointed end which forms a hollow sucker-like cavity in the living condition. He also retained the Japanese species in *Bothrioscolex* because of the similar shape of its scolex which Yamaguti described as : "Constricted off, truncate or conical with irregularly crenulated anterior margin."

The scolex of *Khawia* and *Bothrioscolex* may be said to be different in shape, but this difference alone does not appear to be

sufficient for the generic diagnosis. In fact Szidat (1941) has himself indicated his doubts about separating the two genera on the basis of the very variable scolex. Since the morphological and the histological characters of both the genera are otherwise similar and since Szidat's third species of *Bothrioscolex*, *B. dubius* has a smooth and undifferentiated scolex, it is desirable to regard *Bothrioscolex* as a synonym of the genus *Khawia* which has priority over it.

Including the species of *Bothrioscolex* the total number of species in the genus *Khawia* is now six; these are listed below together with brief description of their characters.

The species of *Khawia*

Khawia sinensis Hsü, 1935

55–95 mm. long, 1·6–2 mm. wide. Flat, fan-shaped scolex with frilled anterior margin. Vitelline follicles not closely aggregated, being mostly arranged in two marginal bands, absent in the ovarian region and only few follicles in the uterine region. Pre-ovarian vitelline follicles in cortical parenchyma but post-ovarian vitelline follicles also present in medullary parenchyma. Cirrus sac and utero-vaginal canal open into common genital atrium. Eggs 46–48 × 26–30 μ.

Intestine of *Cyprinus carpio*. Peiping, China.

Khawia japonensis (Yamaguti, 1934) Hsü, 1935

Syn. *Caryophyllaeus japonensis* Yamaguti, 1934.

Bothrioscolex japonensis (Yamaguti, 1934) Szidat, 1937

10–20 mm. long, 0·87 mm. wide. Type 13 mm. long. Scolex broad, constricted off, truncate or conical with irregularly crenulated anterior margin. Both pre- and post-ovarian vitelline follicles in cortical parenchyma. Eggs 48–57 × 36–42μ.

Intestine of *Cyprinus carpio*. Japan.

Khawia prussicus (Szidat, 1937) n.comb.

Syn. *Bothrioscolex prussicus* Szidat, 1937

10 mm. long. 0·5 mm. wide. Eggs 51–53 × 33–35 μ.

This species is probably a synonym of *K. japonensis*. Szidat (1937) while accepting the similarity between the two species in the measurements and other characters, placed it as a distinct species on the basis of the difference in the host and in the distribution, and the longer uterine coils. These differences do not appear to be of specific value.

Intestine of *Carassius carassius*. East Germany.

Khawia rossettensis (Szidat, 1937) n.comb.

Syn. *Bothrioscolex rossettensis* Szidat, 1937

25 mm. long, 2 mm. wide. Scolex same as in *K. japonensis*, and forms a deep cavity in living worm. Vitelline follicles closely aggregated and located in the cortical parenchyma. Follicles absent in the ovarian region as in *K. sinensis*. Testes arranged in one layer of four in each horizontal row. Eggs 55–62 × 37–40 μ, 7–8 yolk cells in each egg.

Intestine of *Carassius carassius*. East Germany.

Khawia dubius (Szidat, 1937) n.comb.

Syn. *Bothrioscolex dubius* Szidat, 1937

5–6 mm. long, 2–2·5 mm. wide. Short thick form with smooth and slightly wide scolex. Vitelline follicles probably in cortical parenchyma, absent in ovarian region. Ovary with short anterior and posterior horns. Testes in two layers of two in each horizontal row. Eggs 45–49 × 34–36 μ.

Intestine of *Carassius carassius*. East Germany.

Khawia baltica Szidat, 1941

25–30 mm. long. Type 31 mm. long, 2 mm. wide. Scolex flat and fan-shaped as in *K. sinensis*, with small finger-like projections on the anterior border. Vitelline follicles mostly in the cortical parenchyma. A few vitelline follicles present in the ovarian region, thus partly connecting pre- and post-ovarian vitelline follicles. The latter follicles partly surround the lower horns of the ovary. Eggs 59–62 × 42–46 μ, 5–6 yolk cells in each egg.

Intestine of *Tinca tinca*. East Germany.

Revised Generic Diagnosis of *Khawia* Hsü, 1935

Syn. *Bothrioscolex* Szidat, 1937

Lytocestinae : Scolex flat, fan-shaped, spherical, cone-shaped or smooth and undifferentiated. Cirrus and utero-vaginal canal open into a common genital atrium. Uterine coils never extend anterior to cirrus sac. Uterine glands present. Post-ovarian vitelline follicles present. Vitelline follicles generally absent in ovarian region. Pre-ovarian vitelline follicles mostly in cortical parenchyma, and post-ovarian vitelline follicles either in cortical or both in cortical and medullary parenchyma. Parenchymal musculature in single layer.

Parasites of Cyprinid fishes.

Genotype : *Khawia sinensis* Hsü, 1935.

SUMMARY

1. A new Caryophyllaeid cestode *Adenoscolex oreini* n.g., n.sp., from fresh-water fish, *Oreinus sinuatus*, is described.

2. Genus *Bothrioscolex* Szidat, 1937 is regarded as a synonym of the genus *Khawia* Hsü, 1935. The existing species of *Khawia* are listed and are briefly described.

ACKNOWLEDGMENTS

I am thankful to Mr. M. Mallik for the material. I am indebted

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A Review of the Trematode Genus *Astiotrema* in the Family Plagiorchiidae

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The genus *Astiotrema* at present contains the following 21 species :—

1. *Astiotrema reniferum* (Looss, 1898) Genotype.
2. *A. impletum* (Looss, 1899).
3. *A. monticellii* Stossich, 1904.
4. *A. emydis* Ejsmont, 1930.
5. *A. elongatum* Mehra, 1931.
6. *A. loossii* Mehra, 1931.
7. *A. gangeticus* K. R. Harshey, 1932.
8. *A. spinosa* R. C. Chatterji, 1933.
9. *A. indica* Thapar, 1933.
10. *A. rami* Bhalerao, 1936.
11. *A. odhneri* Bhalerao, 1936.
12. *A. orientale* Yamaguti, 1937.
13. *A. amydae* Ogata, 1938.
14. *A. fukuii* Ogata, 1938.
15. *A. dassia* J. Dayal, 1938.
16. *A. foochowensis* Tang, 1941.
17. *A. nathi* N. K. Gupta, 1954.
18. *A. hoshiarpurium* N. K. Gupta, 1954.
19. *A. srivastavai* N. K. Gupta, 1954.
20. *A. thapari* N. K. Gupta, 1954.
21. *A. matthaii* N. K. Gupta, 1954.

Looss (1896) described a new trematode, *Distoma unicum* from the Nile Soft-shelled turtle, *Trionyx nilotica* in Egypt. As the name *Distoma unicum* is a homonym of one of Molin's distomes (1859), Looss (1898) proposed a new name *Distoma reniferum*. The following year, Looss (1899) made *D. reniferum* the type of a new genus *Astia*, and added another species *Astia impleta*, collected from the fresh-water fish, *Tetraodon fahaka* from the Nile. As *Astia* was pre-occupied for an arachnid by Koch, 1879, Looss (1900) proposed the name *Astiotrema*.

Stossich (1904) added a third species, *Astiotrema monticellii* from a snake, *Tropidonotus viperinus* from Italy, and transferred *Distoma erinaceum* Poirier, 1886 to *Astiotrema*. Odhner (1911) redescribed what he took to be *A. reniferum* from *Trionyx triunguis* (= *T. nilotica*) and *A. impletum* from *Tetraodon fahaka*, both from North Africa.

The former species, *A. reniferum* of Odhner has been renamed *A. odhneri* by Bhalerao (1936).

Since Odhner's work (1911), there was a period of lull, and then starting with Ejsmont (1930) and Mehra (1931) and culminating with the work of N. K. Gupta (1954), eighteen new species were added to the genus. Out of this mass of creation, our studies have shown only one of the eighteen to be valid.

Of the total twenty-one species in the genus *Astiotrema*, we propose to transfer *Astiotrema emydis* Ejsmont, 1930 to *Leptophallus* which is its correct genus. Of the remaining species, our studies have shown only four species to be valid. The genus *Gauhatiana* S.P. Gupta, 1955 is congeneric with *Astiotrema*.

Material at our disposal consists of two specimens of *Astiotrema reniferum* from Looss' collection (Types ?) from *Trionyx niloticus* from Egypt ; collections of *A. impletum* from *Tetraodon fahaka* the type host, from the Nile at Sudan ; and one collection of some fifty specimens of *A. reniferum* from a single Ganges Soft-shelled Turtle, *Trionyx gangeticus* from India which died in the London Zoo.

The four species of *Astiotrema* as we recognise them are :—

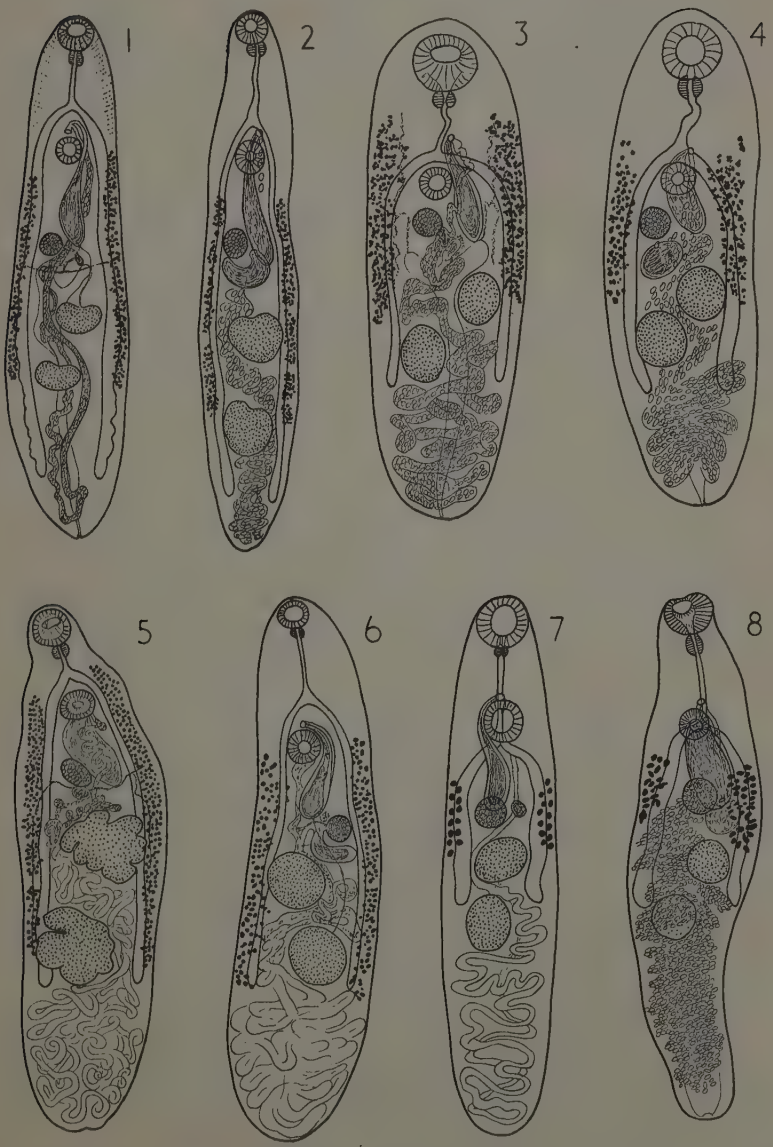
1. *Astiotrema reniferum* (Looss, 1898) Looss, 1900. Genotype.
2. *Astiotrema impletum* (Looss, 1899) Looss, 1900.
3. *Astiotrema monticellii* Stossich, 1904.
4. *Astiotrema odhneri* Bhalerao, 1936.

Astiotrema Looss, 1900

Syns. *Astia* Looss, 1899 *nec* Koch, 1879

Gauhatiana S.P. Gupta, 1955

Generic diagnosis : Plagiorchiidae. Body lanceolate, with cuticular scales. Oral sucker subterminal, prepharynx practically absent. Pharynx moderate in size. Oesophagus moderately long. Caeca reach anywhere between the middle and posterior end of worm. Ventral sucker in anterior half of body ; diameter between half to equal size of oral sucker. Testes intercaecal, tandem or diagonal, in posterior half of body. Cirrus sac long, claviform, extending far posterior to ventral sucker, occupied almost entirely by seminal vesicle. Genital pore median or submedian, anterior to ventral sucker. Ovary usually submedian, mid-way between ventral sucker



Species in the genus *Astiotrema*

Fig. 1.—*A. reniferum* (after Looss, 1896). Fig. 2.—*A. reniferum* (Original). Fig. 3.—*A. impletum* (after Looss, 1899). Fig. 4.—*A. impletum* (Original). Fig. 5.—*A. odhneri* (after Odhner, 1911). Fig. 6.—*A. odhneri* (after Tang, 1941). Fig. 7.—*A. monticellii* (after Stossich, 1904). Fig. 8.—*A. monticellii* (after Dollfus, 1957).

and anterior testis. Seminal receptacle present, usually large. Vitellaria in extracaecal fields, usually extending along middle half of body. Uterine coils reach the posterior extremity. Excretory vesicle Y-shaped, with long stem and short arms.

Intestinal parasites of Reptiles and Fishes.

Genotype : *A. reniferum* (Looss, 1898) Looss, 1900

Syn. *Distoma unicum* Looss, 1896 *nec* Molin, 1859

Key to the species of *Astiotrema*

1. Oral sucker about twice the diameter of ventral sucker; vitellaria restricted to anterior half of worm . . .
. . . *A. impletum* (Looss, 1899) Looss, 1900

— Oral and ventral suckers roughly of equal size . . . 2

2. Caeca terminating about middle of body; vitellaria restricted to second-quarter of body . . .
. . . *A. monticellii* Stossich, 1904.

— Caeca longer than above and vitellaria more dispersed 3

3. Caeca terminating near posterior end of body . . .
. . . *A. reniferum* (Looss, 1898) Looss, 1900

— Caeca terminating about posterior end of second testis
. . . *A. odhneri* Bhalerao 1936

Redescriptions of the species of *Astiotrema*

Astiotrema reniferum (Looss, 1898) Looss, 1900

Syns. *Distoma unicum* Looss, 1896 *nec* Molin, 1859
Distoma reniferum Looss, 1898
Astia renifera (Looss, 1898) Looss, 1899
Astiotrema elongatum Mehra, 1931
A. loossi Mehra, 1931
A. gangeticus K. R. Harshey, 1932
A. spinosa R. C. Chatterji, 1933
A. indica Thapar, 1933
A. rami Bhalerao, 1936
A. dassia J. Dayal, 1938
A. hoshiarpurium N. K. Gupta, 1954
A. thapari N. K. Gupta, 1954
Guahatiana batrachii S.P. Gupta, 1955

Hosts.

Fish : *Clarias batrachus* (Burma, India)

Turtles and Tortoises : *Trionyx triunguis* (=*T. nilotica*) (North Africa), type host, *Chitra indica, Emyda granosa, Kachuga dhongoka, K. kachuga, Lissemys punctata* and *Trionyx gangeticus* (India).

Distribution : North Africa, Burma and India.

With the exception of *A. gangeticus* which has previously been placed under synonymy, the above list are all new synonyms.

The species *Astiotrema reniferum*, type of the genus *Astiotrema*, having twice changed its name by Looss (1896, 1898, 1900) was rechristened nine times over. It was first reported by Looss (1896), from the Nile Soft-shelled Turtle, *Trionyx nilotica* in Egypt as *Distoma unicum*. Being a homonym, it was changed to *Distoma reniferum* by Looss (1898) and later in the same year, made the type of a new genus *Astia*. The latter genus being preoccupied, the name was changed to *Astiotrema*.

Odhner (1911) redescribed a so-called *A. reniferum* from *Trionyx triunguis* (=*T. nilotica*) from North Africa. This worm, however, was rightly renamed by Bhalerao (1936) as *Astiotrema odhneri*.

This parasite has been collected from various hosts—fish, tortoises and turtles. They are usually found in small numbers, but occasionally in large numbers. Our collection consists of some fifty specimens from one host.

These are elongated worms. The breadth varies greatly, but generally it is broadest at the middle and attenuates slightly anteriorly and posteriorly. The anterior end of the worm is bent ventrally. The cuticle is invested with scales, dense in the anterior half of the worm, but becoming more and more sparse towards the caudal end. The oral and ventral suckers are roughly equal in size. There is practically no prepharynx, a moderately developed pharynx, and a fairly long oesophagus. The caeca terminate posterior to the testes and near the posterior extremity of the worm. The ventral sucker is situated immediately posterior to the bifurcation of the gut.

The testes are tandem in position. They vary greatly in shape from spherical with almost smooth borders to lightly or deeply lobed. The cirrus sac is large, and extends to the region of the ovary. It is more or less median in position. The seminal vesicle is large and fills most of the cirrus sac. The oval pars prostatica is short and surrounded by prostate cells. The cirrus occupies a small anterior

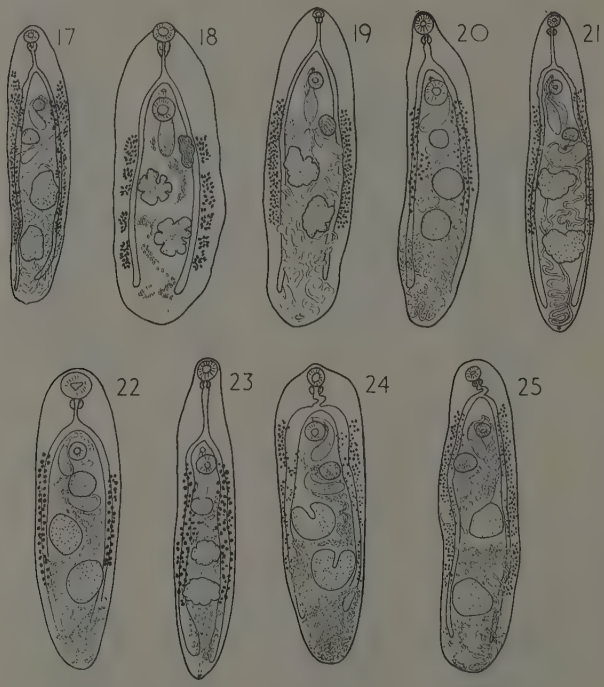
* Tabulated below are measurements of *A. reniferum* taken from ten random specimens, all of which were collected from a single *Trionyx gangeticus*.

Length	4·1	2·3	2·9	5·4	6·6	6·3	4·3	3·2	5·8	3·2
Width	0·74	0·73	0·60	0·82	1·09	1·07	0·82	0·98	0·96	0·93
Oral sucker	0·24	0·27	0·24	0·31	0·35	0·29	0·25	0·26	0·24	0·26
Ventral sucker	0·24	0·25	0·24	0·27	0·35	0·30	0·24	0·24	0·27	0·27
Ovary	0·18	0·15	0·16	0·20	0·22	0·25	0·20	0·21	0·24	0·20
Ant. testis	0·44	0·29	0·34	0·47	0·62	0·56	0·47	0·47	0·62	0·45
Post. testis	0·51	0·31	0·33	0·54	0·71	0·73	0·41	0·49	0·69	0·44
Cirrus pouch length	0·93	0·51	0·82	0·85	1·49	1·16	0·95	1·06	1·09	0·69
Eggs	38×19	36×19	36×20	38×20	38×19	44×20	42×19	38×17	44×19	40×19
	42×21	34×21	38×19	42×21	42×19	44×19	40×17	38×17	44×19	40×21

* All measurements are in mm. except those of the eggs which are in microns.

Figs. 9–16.—*Astiotrema reniferum*, original drawings to show variations of specimens taken from a single host.

part of the cirrus sac. The male opening lies to the right and the female opening on the left of the shallow genital atrium which opens on the median anterior border of the ventral sucker.



Figs. 17–25.—*Astiotrema reniferum* (Looss, 1898)

These were formerly known as :

Fig. 17.—*A. elongatum* Mehra, 1931. Fig. 18.—*A. loossi* Mehra, 1931. Fig. 19.—*A. gangeticus* Harshey, 1932. Fig. 20.—*A. spinosa* Chatterji, 1933. Fig. 21.—*A. indica* Thapar, 1933. Fig. 22.—*A. rami* Bhalerao, 1936. Fig. 23.—*A. dassia* Dayal, 1938. Fig. 24.—*A. hoshiarpurium* Gupta, 1954. Fig. 25.—*A. thapari* Gupta, 1954.

The ovary is usually oval, slightly antero-posteriorly elongated. It generally lies slightly to the right. The oviduct arises from the posterior median side and is soon joined by a large kidney-shaped seminal receptacle which lies on the posterior border of the ovary and soon after it receives a short duct from the vitelline reservoir.

The ootype, median in position, is surrounded by Mehlis' gland. The follicular vitellaria extend along the lateral fields of the worm, usually from the posterior level of the ventral sucker to the middle of the posterior testis. The uterus descends to the caudal end of the worm, taking an S-shape to squeeze between the two testes, and ascends after reaching the caudal end. The thin-shelled operculated eggs are numerous.

Astiotrema impletum (Looss, 1899) Looss, 1900

Syn. *Astia impleta* Looss, 1899

Host : *Tetraodon fahaka*, fish.

Distribution : North Africa.

This species is known only from North Africa from the fresh-water fish, *Tetraodon fahaka*. We have at our disposal collections from the type host from Sudan.

Measurements of six specimens in mm. and eggs in microns are as follows :—

Length	1·8	1·8	1·9	2·5	2·6	3·5
Width	0·79	0·82	0·82	0·82	0·87	1·07
Oral sucker	0·35	0·34	0·35	0·37	0·35	0·43
Ventral sucker	0·20	0·19	0·18	0·20	0·19	0·25
Ovary	0·16	0·16	0·13	0·16	0·16	0·22
Ant. testis	0·22	0·21	0·22	0·29	0·27	0·36
Post. testis	0·24	0·21	0·22	0·32	0·30	0·38
Cirrus sac length ...	0·35	0·40	0·36	0·45	0·47	0·66
Eggs	42×17	42×17	42×17	40×21	38×17	42×17
	42×17	42×19	46×17	42×17	42×17	44×17

These are small stoutish worms ending abruptly at both ends. The anterior third of the worm is densely invested with cuticular scales which become very sparse in the posterior parts of the worm. The oral sucker is large and twice that of the ventral. There is a short prepharynx, a relatively stout pharynx and a moderately developed oesophagus. The caeca terminate at the posterior border of the second testis or the junction of the third- and fourth-quarters of the body.

The testes are smooth, slightly diagonal in position, usually with the anterior one to the left and the posterior one to the right. The cirrus sac is large and extends to the posterior border of the ovary. It is more or less in a median position. The seminal vesicle

is large and fills most of the cirrus sac. The short pars prostatica is enveloped by prostate cells and terminates in a short stout cirrus. The male opening lies on the right and the female opening on the left of the shallow genital atrium which opens in the area of the bifurcation of the gut.

The spherical ovary is slightly displaced to the right. The oviduct arises on the median posterior side, and is soon joined by a large oval-shaped seminal receptacle which lies on its posterior border, and soon afterwards it receives a short duct from the vitelline reservoir. The ootype, median in position, is surrounded by a mass of Mehlis' gland. The follicular vitellaria extend along the lateral fields of the worm, occupying an area between the middle of the oesophagus to the level of the posterior border of the anterior testis. The uterus descends between the testes to the caudal end before ascending to the genital pore. There are numerous thin-shelled elongated eggs.

Astiotrema monticellii Stossich, 1904

Host : *Natrix viperina* (type host), *N. natrix* var. *persa*

Distribution : Italy

This species had been amply redescribed by Dollfus (1957) from whom the following description and measurements are mainly taken. His measurements of three specimens in mm. and eggs in microns are :—

Length	2·2	2·2	2·4
Width	0·5	0·5	0·3
Oral sucker	0·16	0·17	0·17
Ventral sucker	0·13	0·14	0·13
Ovary	0·14	0·15	0·13
Ant. testis	0·26	0·21	0·23
Post. testis	0·24	0·22	0·21
Cirus sac length ...	0·60	0·41	0·52
Eggs	31×11	28×11	22×11
	29×14	21×11	26×14

This is a narrowish elongated worm, slightly attenuated at both ends and four to seven times as long as broad. The anterior part is densely invested with scales which become very sparse towards the caudal end. The subterminal oral sucker is slightly larger than the ventral sucker. A very short pre-pharynx is present together

with a moderately sized pharynx and oesophagus. The caeca are short and terminate between the two testes or about the middle of the body. The ventral sucker is relatively far forward, and lies in a region slightly anterior or posterior to the bifurcation of the gut.

The testes are rounded, tandem or slightly diagonal in position. The large saccular cirrus pouch which is median in position and filled mainly by the seminal vesicle reaches the level of the ovary. The genital opening is immediately anterior to the border of the ventral sucker.

The spherical ovary is median or submedian. The seminal receptacle is large. The vitellaria have large follicles and are situated on the lateral fields and restricted to the third-sixth of the body length. The uterus descends between the testes and reaches the caudal end before ascending to the genital pore. There are numerous thin-shelled operculated eggs.

Astiotrema odhneri Bhalerao, 1936

Syns. *Astiotrema reniferum* of Odhner, 1911 *nec* Looss, 1898
A. orientale Yamaguti, 1937
A. amydae Ogata, 1938
A. fukuii Ogata, 1938
A. foochowensis Tang, 1941
A. nathi N. K. Gupta, 1954
A. srivastavai N. K. Gupta, 1954
A. matthaii N. K. Gupta, 1954

Hosts : *Trionyx triunguis* (=*T. nilotica*) type host North Africa ; *Amyda japonica* (Japan), *A. maackii* (Korea), *A. tuberculata* (China), and *Lissemys punctata punctata* (India).

Distribution : North Africa, China, India, Korea and Japan.

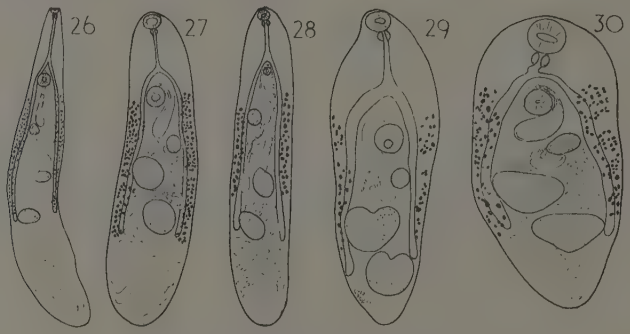
With the exception of *A. amydae* and *A. foochowensis* which have previously been placed under synonymy, the above list are all new synonyms.

The following descriptions and measurements in mm. and eggs in microns are taken mainly from Odhner (1911).

Length	4–5
Width	1
Suckers	0·25–0·3
Testes	0·45–0·65
Eggs	26–29 × 11

The worms are elongated and slightly attenuated at both ends. The cuticle is thickly covered with scales in the anterior part but

becomes very sparse towards the caudal end. The oral and ventral suckers are roughly equal in size. The pharynx and oesophagus are moderately developed. The caeca terminate at the posterior border of the second testis or between the third- and fourth-quarter of the body.



Figs. 26–30.—*Astiotrema odhneri* Bhalerao, 1936

These were formerly known as :
Fig. 26.—*A. orientale* Yamaguti, 1937. Fig. 27.—*A. foochowensis* Tang, 1941. Fig. 28.—*A. nathi* Gupta, 1954. *Fig.* 29.—*A. srivastavai* Gupta, 1954. Fig. 30.—*A. matthai* Gupta, 1954.
Figs. 17–30 are after original authors.

The large testes may be smooth or lobed, and tandem or slightly diagonal in position. The large cirrus sac which is median in position and occupied mainly by the seminal vesicle has the posterior end extending to the region of the ovary. The genital pore is on the immediate anterior border of the ventral sucker.

The ovary is small, rounded or slightly elongated, median or usually submedian in position. There is a large seminal receptacle. The follicular vitellaria extend along the lateral fields of the worm between the ventral sucker and the posterior level of the second testis. The uterus descends between the testes to the caudal end in voluminous coils and fills the entire space before ascending to the genital pore. There are many thin-shelled elongated eggs.

Discussion

When first confronted with the material, it was found impossible to assign it to any particular species as existing literature suggested our material had about a dozen species. The keys did not

serve our purpose and the accounts of many of the later authors were inaccurate in description, fact or nomenclature. N. K. Gupta (1954) in describing *A. hoshiarpurium*, Fig. 2, distinctly draws a prepharynx, but the text reads "The prepharynx is absent". In his key to the species, *A. odhneri* Bhalerao, 1936 is referred to as *A. odhneri* (Odhner, 1911) Bhalerao, 1936. In his bibliography, Looss (1898) is quoted as "Looss, A. (1898). Recherches sur la Fauna parasitaire de L'Egypt. *Zbl. Bakt.*, XXIII, p. 461", a mistake repeated from Thapar (1933). Such inaccuracies are numerous, and it is not our intention to list them here. With this unwieldy situation in the literature, we decided to make a critical study of the genus.

Testes. Mehra (1931) unfortunately chose the testes as the main basis for separating *A. elongatum* Mehra, 1931 from *A. loossi* Mehra, 1931. Consequently this unacceptable character has been repeatedly used by later authors to cause greater burden in the literature of systematics. Our observations as we have depicted in Figs. 9–16, shows a great variation in the lobation of the testes from smooth to greatly lobed. We therefore believe this character to be of little specific importance.

Suckers. Bhalerao (1936) using as an important character the ratios of the oral and ventral suckers constructed a key to the species of *Astiotrema*. He divided them first into three groups, with *oral and ventral suckers equal*, with *oral sucker smaller than ventral sucker*, and *oral sucker larger than ventral sucker*. N. K. Gupta (1954) after adding five species to the genus, brought the key up-to-date. His key literally used the third decimal place in millimetres to separate the three groups, oral sucker equal, smaller or larger than ventral sucker . . . a useful key for the separation of type drawings in the literature.

We believe the sucker measurements or ratios may be useful in some instances, but it cannot be used to the third decimal place. In *A. impletum* the oral sucker is roughly twice that of the ventral sucker. In the remaining three species, viz., *A. reniferum*, *A. monticellii* and *A. odhneri* the two suckers are roughly of equal size, and a comparison of the suckers cannot be used. Our measurements of ten specimens of *A. reniferum* taken at random show the suckers in three specimens to be equal in size, four with oral suckers larger than ventral, and three with oral sucker smaller than ventral sucker.

Prepharynx. From the study of available material, we believe a short prepharynx to be present in all species. This character is of no specific importance.

Oesophagus. The oesophagus has been depicted by many authors to be of varying lengths. Many of these authors had only one or two specimens and often much distorted as shown in their drawings. In unpressed material, we have found the anterior end to have a tendency to curl ventrally as was our experience with other trematodes. When it is so mounted and studied, it gives a grossly false impression of the true length of the oesophagus. We have purposely drawn Fig. 14 to show the situation. However, in carefully prepared specimens, we have found the oesophagus to be fairly constant in its length, although it cannot be used to any advantage in specific diagnosis.

Caeca. In fully developed specimens, we have found the length of the caeca to be a very useful taxonomic character in this genus. In *A. monticellii* it is short, in *A. impletum* and *A. odhneri* it is intermediate, while in *A. reniferum* it is always long and almost reaches the posterior end of the worm.

Vitellaria. The distribution of the vitellaria is important. In *A. monticellii* it has large follicles and is much restricted in its distribution. Its distribution in *A. reniferum* and *A. odhneri* is much the same. However, it is necessary to use with some discretion the distribution of vitellaria as a systematic character, although some authors have in the past separated species with a few follicles passing a certain dead line—"Vitellaria extend cephalad from ventral sucker" or "Vitellaria do not extend cephalad to ventral sucker".

Host specificity. Astiotrema impletum has been reported from freshwater fish only, *A. monticellii* from snakes only, *A. odhneri* from tortoises and turtles, while *A. reniferum* is recorded from one species of freshwater fish and several species and genera of turtles and tortoises. The latter species is found in a comparatively diverse number of hosts, but it is not surprising when we take into consideration how closely related the hosts are ecologically. There do not appear to be any difference noticeable in the morphology of the parasites collected from the fish, turtle or tortoise.

Summary

In a critical review of the genus, the authors after studying ample material arrived at the conclusion that only four of the twenty-one species are valid. The shape of the testes is shown to vary from smooth to deeply lobed, and minor differences in the sucker ratios are considered invalid.

The species recognised with their synonyms are :—

(1) *Astiotrema reniferum* (Looss, 1898) (Syns. *A. elongatum* Mehra, 1931, *A. loossi* Mehra, 1931, *A. gangeticus* K. R. Harshey, 1932, *A. spinosa* R. C. Chatterji, 1933, *A. indica* Thapar, 1933, *A. rami* Bhalerao, 1936, *A. dassia* J. Dayal, 1938, *A. hoshiarpurium* N. K. Gupta, 1954 and *A. thapari* N. K. Gupta, 1954, *Guahatiana batrachii* S. P. Gupta, 1955.)

(2) *A. impletum* (Looss, 1899).

(3) *A. monticellii* Stossich, 1904.

(4) *A. odhneri* Bhalerao, 1936 (Syns. *A. orientale* Yamaguti, 1937, *A. amydae* Ogata, 1938, *A. fukuii* Ogata, 1938, *A. foochowensis* Tang, 1941, *A. nathi* N. K. Gupta, 1954, *A. srivastavai* N. K. Gupta, 1954, *A. matthaii* N. K. Gupta, 1954).

The species *Astiotrema emydis* Ejsmont, 1930 is transferred to the genus *Leptophallus*. The genus *Guahatiana* S. P. Gupta, 1955 is a synonym of *Astiotrema*.

ACKNOWLEDGMENTS

We wish to express our gratitude to Professor J. J. C. Buckley for his interest in the study and to Mr. S. Prudhoe of the British Museum (Nat. Hist.) for the loan of some of the Museum collection, which also includes material from Looss' original collection.

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On Some Trematode Parasites from the Jackdaw, *Corvus monedula* in Britain

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During the course of a survey of the internal parasites of the Jackdaw undertaken between November 1953 and June 1954 at the Imperial College of Science and Technology, London, two trematodes apparently new to the British fauna were discovered and have been identified as *Urotocus thalonetensis* Timon-David, 1955, and *Tamerlania zarudnyi* Skrjabin, 1924.

Of sixteen birds examined, four were found to be infested with trematodes representing five species, one bird being infested with two species, namely *Platynosomum petiolatum* and *Urotocus thalonetensis*.

With the exception of the material of *Lyperosomum longicauda* all the specimens were living when found and were fixed in formol-acetic, stained in aceto-carmine and mounted in DePeX.

Urotocus thalonetensis Timon-David, 1955

Four specimens of this trematode (Figs. 1–3) were found in the bursa Fabricii of a single Jackdaw from the field station of the London School of Tropical Medicine at Winches Farm near St. Albans. Unfortunately they were damaged while being removed from the bird, with the result that only one complete specimen, and portions of two others were available for study. The complete specimen was fixed under coverslip pressure, stained, and examined in creosote before mounting.

As a preliminary examination suggested a new form without a ventral sucker but with a Brachylaemid reproductive system, it was decided to cut a series of transverse sections for a more detailed investigation, and the damaged portions of the flukes were used for this purpose. Unfortunately no sections could be obtained of the extreme posterior end as none of the fragments included this region.

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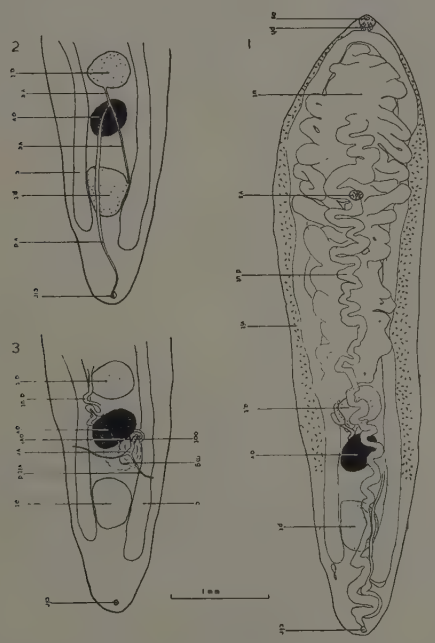
From these sections a detailed picture of the genital complex was obtained and the presence of a minute, poorly developed ventral sucker was discovered. It was due to this last discovery that the fluke was readily determined as being a member of the genus *Urotocus*.

The following description is based mainly on the one complete specimen available, with details of the excretory system and genital complex obtained from a study of the sections. The body is fusiform, measuring 10 mm. long by 1·3 mm. wide, and is flattened on the ventral surface. It is covered with fine triangular spines which are to be found in greater abundance on the ventral surface of the anterior half of the body. The oral sucker tends to be slightly sub-terminal and ventral, measuring 0·13 mm. in diameter and opening directly into a short muscular pharynx. A short oesophagus opens into two wide caeca which extend laterally and run parallel to the lateral margins, almost to the posterior end of the body. These caeca are filled with a dark substance which appears to be composed of undigested blood-corpuscles. A very small (0·085 mm. by 0·067 mm.) ventral sucker is situated at about the anterior fourth of the body, but this was not detected in living or cleared specimens.

The excretory pore is terminal and opens into a V-shaped vesicle whose arms extend almost to the oral sucker. This configuration appears to be rather doubtful as in serial sections two large canals may be seen on each side of the body. It is probable that the general plan is similar to that described by Dollfus (1934) for the Brachylaemidae, namely, a pair of fine canals run on each side of the body from the anterior to the posterior end. In the latter region each pair unites to form a single large canal which runs forward again almost to the oral sucker, then conversely to the excretory pore. The two canals seen in the sections are probably the two loops of the large canal.

The male reproductive system consists of two somewhat ovoid testes lying, one in front of, and the other behind, the ovary, in the posterior third of the body. The anterior testis lies adjacent to the ovary, while the posterior one lies a distance equal to its long axis behind the ovary. The vas efferens from the posterior testis extends forward until it joins that from the anterior testis and both form a wide vas deferens which runs ventrally to open into the sub-terminal posterior genital pore. The copulatory organs can be seen in the whole specimen to consist of a short broad cirrus, but the extent of the cirrus pouch and seminal vesicle is unknown, due to the absence of

sections at this point and the presence of a gravid portion of the uterus in the whole mount.



Urotocus thalonetensis Timon-David

Fig. 1.—Ventral view of whole worm. Fig. 2.—♂ reproductive system. Fig. 3.—♀ reproductive system

Abbreviations used in Figures

a.t=anterior testis ; **a.ut**=ascending limb of uterus ; **c**=gut caecum ; **cir**=cirrus ; **cp**=cirrus pouch ; **d.ut**=descending limb of uterus ; **ex**=excretory pore ; **gp**=genital pore ; **mg**=Mehlis' gland ; **oes**=oesophagus ; **oot**=ootype ; **os**=oral sucker ; **ov**=ovary ; **ovi**=oviduct ; **ph**=pharynx ; **p.t.**=posterior testis ; **t**=testis ; **ut**=uterus ; **ve**=vas efferens ; **vd**=vas deferens ; **vit**=vitellaria ; **vit.d**=vitelline duct ; **vit.r**=vitelline reservoir ; **vs**=ventral sucker.

The female system consists of an ovary, slightly smaller than the testes, with a short oviduct leading to the oötype and vitelline reservoir, both of which are surrounded by Mehlis' gland. The

follicular vitelline glands extend from just behind the pharynx to the posterior margin of the ovary and are confined to the extra-caecal fields. From the oötype, the uterus runs dorsally to the ovary and extends forward in a large number of coils, filling the space between and often overlapping the caeca until it reaches the intestinal bifurcation. From here a single slightly coiled descending limb extends back ventrally to open into the genital pore. For the reasons already given it is not known if the female pore is separate from that of the male.

The eggs are thick shelled, measuring 0·025 mm. by 0·018 mm. in the region of the genital pore where they are a deep brown.

The specimens have been deposited with the British Museum (Natural History) London.

Discussion

The genus *Urotocus* has been reported on only four previous occasions. The first by Mühling (1898), from a Fieldfare, *Turdus pilaris* from E. Prussia when he described the form under the name of *Urogonimus rossitensis* which Looss later designated as the type species of *Urotocus*. The other occasions have been reported by McIntosh (1935) and McIntosh and McIntosh (1935) from three different warblers in Washington D.C., U.S.A. These specimens McIntosh has named *U. fusiformis*. Recently Timon-David (1955) has described a number of specimens of *Urotocus* from the Magpie in Aix en Provence and he has separated these from both *rossitensis* and *fusiformis* and calls them *U. thalonetensis*.

The distinguishing features of each species are as follows :—

U. rossitensis

A small ventral sucker lies almost in the centre of the body.

The posterior testis lies between the tips of the caeca.

The gonads lie in the last quarter of the body.

The anterior extension of the vitellaria does not reach the junction of the caeca.

U. fusiformis

A ventral sucker has not been detected in living or fixed specimens.

The posterior testis is removed from the tips of the caeca by a distance equal to its diameter.

The vitellaria reach the pharynx.

The gonads lie in the last quarter of the body.

U. thalonetensis

The ventral sucker lies at the junction of the first and second fifths of the body.

The caeca extend well past the posterior testis and are slightly bulbous at the end.

The anterior testis is near the centre of the body.

The vitellaria reach the pharynx.

From a study of these characters it will be noted that the material described in this paper conforms with *fusiformis* in that 1. the ventral sucker could not be detected in living or fixed specimens, but only in sections ; 2. the posterior testis is removed from the tips of the caeca by a distance equal to its diameter ; and 3. the vitellaria almost reach the pharynx.

It is similar to *thalonetensis* in that 1. the ventral sucker is present near the first quarter of the body length, and 2. the vitellaria almost reach the pharynx.

It resembles *rossitensis* in that 1. a very small ventral sucker is present, and 2. the gonads lie almost in the last quarter of the body.

It was decided to refer this material to *U. thalonetensis* because it most closely resembles Timon-David's description and was not considered sufficiently different from the named forms to warrant the erection of a new species. It does however seem to combine some of the characters of the three species already described, and it may eventually transpire that these are in fact varients of the same species.

Lyperosomum longicauda Braun, 1896

One specimen of this trematode (Fig. 4) was found in the gall-bladder of a Jackdaw from Rothamstead Experimental Station, Hertfordshire.

The body is filiform, 7·6 mm. long and 1·1 mm. broad, flattened dorso-ventrally with a smooth cuticle. The oral sucker (0·29 mm. by 0.32 mm.) opens ventrally and is slightly sub-terminal, leading directly into a well developed muscular pharynx. The ventral sucker lies at the end of the anterior quarter of the body and is large and powerful, measuring 0·72 mm. in diameter. The gut caeca are narrow leading off a short oesophagus and terminating somewhere in the posterior third of the body (the exact position could not be seen owing to the dense folds of the uterus).

The testes lie one behind the other in front of the ovary; both are transversely oval, measuring 0·25 mm. by 0·19 mm. The genital pore lies ventrally just behind the pharynx; the cirrus sac (approx. 0·45 mm. by 0·19 mm.) contains a large cirrus. The ovary is transversely elongate and much larger than the testes (0·35 mm. by 0·25 mm.), Mehlis' gland is well developed, lying directly behind and adjacent to the ovary, from which arises the uterus whose convoluted ascending and descending limbs fill the whole of the posterior half of the body.

The vitellaria are follicular, extending laterally from the posterior border of the anterior testis to half way between the ventral sucker and the posterior end of the body. The excretory pore is posterior and terminal. The eggs are thick shelled and measure 0·021–0·023 mm. by 0·023–0·026 mm.

Prosthogonimus ovatus Rudolphi, 1803

Eight specimens of this trematode were found in the Bursa Fabricii of a single Jackdaw from Winches Farm near St. Albans. All were adult, varying in size from 3·62–4·21 mm. in length and from 2·11–2·24 mm. in breadth.

As this is an extremely common parasite there is nothing to be gained by giving a description. One point however is worth noting, even though there were eight of these parasites in a single location

there does not seem to be any reduction in size amongst them, when compared with those taken from single infestations.

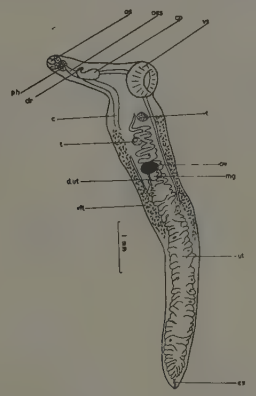


Fig. 4.—*Lyperosomum longicauda* Braun. Ventral view.

Platynosomum petiolatum (Railliet, 1900)

Two specimens (Nos. 1 and 2) were found together in the gall bladder of a single Jackdaw from Winches Farm near St. Albans, (Figs. 5 and 6).

The body is cylindrical and greatly extensible, widest at the area of the ventral sucker and tapering towards either end ; measuring (1) 2·5 mm. by 0·73 mm. and (2) 2 mm. by 0·59 mm. The cuticle is covered with very small spines giving the fluke a rough appearance.

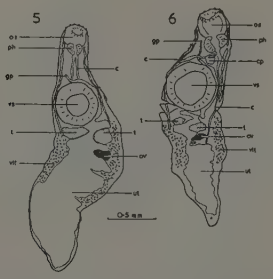
The deep terminal cup-shaped oral sucker measures 0·26 mm. by 0·15 mm. in one specimen (1) and 0·3 mm. by 0·19 mm. in the other (2) and is armed on its lips by a ring of ten to twelve large papillae and numerous smaller ones. The ventral sucker is large and powerful, measuring 0·45 mm. (1) and 0·51 mm. (2) in diameter. It is situated at the end of the anterior third of the body.

Rising directly from the oral sucker, a muscular pharynx opens into a short oesophagus, from which the narrow caeca extend well into the posterior half of the body, their ends being obscured by the gravid uterus.

The actual position of the genital pore in these specimens is uncertain, but it is most probably situated just behind the pharynx. The seminal vesicle and cirrus pouch are just visible in front of the ventral sucker in one specimen (2).

Two transversely-oval testes lie side-by-side just behind the ventral sucker, with the ovary just posterior to the left testis. The ascending and descending limbs of the uterus fill most of the body behind the gonads, there being no folds in front of the ventral sucker.

The vitellaria are follicular, extending laterally from just anterior to the testes to the beginning of the posterior third of the body. The eggs are thick shelled, brown, and measure 0·03 mm. by 0·024 mm.



Platynosomum petiolatum Raillet

Fig. 5.—Ventral view, specimen 1. **Fig. 6.**—Ventral view, specimen 2.

Discussion

This parasite is definitely of the genus *Platynosomum*, but the specific identity is somewhat uncertain. Travassos (1949) gives a very similar description for *Lyperosomum petiolatum*, but neither this nor any other description quite fits this material, and as the classification of this family appears to be rather confused it is suggested that *P. petiolatum* is the most suitable name for this present material, as this species has already been recorded from a Jay by Railliet (1900), whose description Travassos has taken into account, and from British Jays by Baylis (1939).

Tamerlania zarudnyi Skrjabin, 1924.

Ten specimens of this trematode (Fig. 7) were found in the upper portions of the ureters of one Jackdaw from the Imperial College Field Station at Silwood Park, Berkshire. Four of these were damaged on removal from the bird, thus leaving six whole specimens. The principle measurements of these worms are given in Table I.

Table I

No.	*Total Length*	*Breadth*	*Diam. of Oral Sucker*	*Egg Size*
1.	3 mm.	0·74 mm.	0·24 mm.	0·023 mm. by 0·037 mm.
2.	3·5 mm.	0·74 mm.	0·26 mm.	0·026 mm. by 0·040 mm.
3.	3·5 mm.	0·85 mm.	0·30 mm.	0·023 mm. by 0·037 mm.
4.	4 mm.	0·80 mm.	0·32 mm.	0·025 mm. by 0·040 mm.
5.	4·5 mm.	0·93 mm.	0·38 mm.	0·027 mm. by 0·037 mm.
6.	4 mm.	1·0 mm.	0·38 mm.	0·027 mm. by 0·040 mm.

The presence of a ventral sucker could not be detected in living or mounted specimens, so series of transverse sections were cut from the damaged worms to determine this.

The body is fusiform and dorso-ventrally flattened ; the cuticle is covered with small scales which are slightly larger at the anterior end. A fairly powerful oral sucker lies sub-terminally on the ventral surface opening directly into a small pharynx. The ventral sucker could be seen in sections as a very slight thickening of the ventral body-wall between the testes. It is about 0·01 mm. in diameter.

As both pre-pharynx and oesophagus are absent, the gut caeca divide directly behind the pharynx, and run laterally on either side of the body, uniting a short distance from the posterior end. In living and in unstained preserved specimens they are filled with a green substance.

The genital pore, like the ventral sucker, could not be seen in the mounted specimens but in the sections it was found to lie just in front of the ovary in the anterior third of the body. A large cirrus and a seminal vesicle have also been seen in the sections to lie just behind the genital pore. The testes lie side-by-side between the caeca just behind the ovary in the anterior third of the body. They are rather irregular in shape with uneven edges, and mainly broader than they are long. A transversely-oval ovary lies just in front of the testes on either the left or the right side of the body, with a very prominent Mehlis' gland lying just behind it.

The vitellaria are follicular, lateral to the gut caeca, and extending from the level of the testes to the posterior third of the body. The ascending and descending limbs of the uterus completely fill the posterior half of the body and extend forward to the level of the pharynx.

The eggs are provided with thick brown shells measuring from 0·023–0·027 mm. by 0·037–0·04 mm.

The specimens have been deposited with the British Museum (Natural History) London.

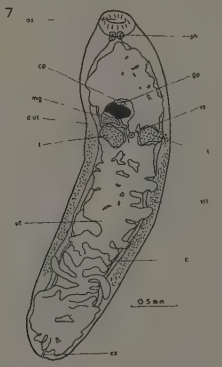


Fig. 7.—*Tamerlania zarudnyi* Skrjabin. Ventral view.

Discussion

The genus *Tamerlania* was erected in 1924 by Skrjabin for a parasite from *Passer montanus* in Russian Turkestan. Since then a number of other species from a variety of hosts has been reported, mainly from Europe but none appear to have been found in Britain. Revisions of the group have been made by Byrd and Denton (1950) and by Teixeira de Freitas in 1951.

In 1946 Dollfus recognised six genera in the family Eucotylidae, but Teixeira de Freitas, taking into account the great variability in the position of the gonads, admits to two genera only, namely, *Eucotyle* and *Tanaisia*, the last containing the old genus *Tamerlania*

among others. However as there still remains some doubt as to the merits of this classification the old generic name of *Tamerlania* has been retained in this work.

As far as can be determined, this is the first record of a species of the *Eucotylidae* being found in Britain. This is somewhat surprising as it is fairly common in Europe, and migration across the channel is frequently undertaken by some of the host species of birds.

Summary

Of a total of sixteen Jackdaws examined, four were found to be infected with Trematodes. These yielded a total of five species, two of which are new to the British fauna, namely *Urotocus thalonetensis* and *Tamerlania zarudnyi*. The other parasites found were *Platynosomum petiolatum*, *Lyperosomum longicauda* and *Prosthogonimus ovatus*. With the exception of *P. ovatus* all the species are described in the text.

The material of *U. thalonetensis* and *Tamerlania zarudnyi* has been deposited with the British Museum (Natural History), London.

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Control of the Common Poultry Ascarid by Treating the Soil with Sodium Pentachlorophenate

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A soil phase is present in the life cycle of most of the nematode parasites of domestic animals. Usually this begins with the passage of eggs or larvae in faeces which soon become a part of the surface layer of the soil or litter. In many species the eggs hatch in the soil and after one or more moults the larvae reach the third (infective) stage. Because of the free-living larval stages of this group of nematodes, they have proved more susceptible to adverse environmental factors such as heat, cold, dessication and the action of chemical disinfectants. Therefore, control methods based on sanitation, disinfection, and rotation to less infested pastures have in some instances been successful.

Species of parasites which do not hatch in the soil, but utilize the shell for protection until they are ingested by the host, have been still more difficult to control. They are much less susceptible to natural adverse factors, and in the past have been considered entirely resistant to chemical disinfection at practical concentrations.

Cameron, 1952, states "there is no good chemical disinfectant for larvae enclosed in their eggshells and disinfectants for this purpose are practically useless. . . ."

Several investigators have studied the bionomics of the soil stages of ascarid and heterakid eggs. Nishimura, 1952, demonstrated that 30–40% of the ascarid eggs in infested soil will contain living embryos after enduring a winter of severe weather. Izumi, 1953, in biological studies on ascarid eggs, found extreme resistance to dehydration and chemical treatment. Farr, 1956, reported that *Heterakis*, *Ascaridia*, and *Capillaria* eggs remained viable and infective in the soil for 66 weeks at Beltsville, Maryland. In 1953, Jaskoski found that the ascarid embryo became vulnerable to chemical attack only after the external coat was removed from the egg by treatment with 10% sodium hydroxide.

Attempts to control endoparasites by destroying the extra-host stages in the soil or litter have been reported. Taylor *et al.* 1943,

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successfully controlled infective larvae, eggs and intermediate hosts of many parasites by soil fumigation with methyl bromide. Edgar and King, 1955, found methyl bromide fumigation successful in the sterilization of poultry litter. Hoerlein, 1951, found that sodium borate was an excellent soil larvicide for dog hookworms. More recently Alicata, 1953, reported the lethal action of polyborate on swine kidney worm larvae in the soil.

The purpose of this paper is to report the effect of chemical treatment of litter on the incidence of infection of poultry by *Ascaridia lineata*.

Methods and Material

A long pen, 56×7 ft. was so constructed that transverse partitions could be placed at 7 ft. intervals to permit division of the long pen into eight units, 7×7 ft. square.

One hundred and eighty young cockerels, 5–6 weeks old, were artificially infected by pipetting approximately 250 eggs of *A. lineata* directly into the crop of each chick. These infected chicks were maintained on a standard poultry feed and allowed free range of the long pen for approximately four months. During this period the litter remained undisturbed while the droppings built up the level of infestation in the pen.

At the end of the four month period the infected cockerels were removed from the original pen, and partitions were installed in preparation for the final part of the experiment.

Previous in-vitro studies by Santmyer, 1956, had shown that sodium pentachlorophenate* at concentrations as low as 10 parts per million had rendered *A. lineata* eggs uninfective. Additional studies had demonstrated the devitalizing effect of certain wetting agents, the alkyl polyamines which cause swelling and distortion of ascarid eggs. These compounds are also markedly toxic to larval and adult nematodes. Another class of compounds which were studied, the benzyl chlorophenols, were found to be very toxic to larval and adult nematodes, but only partially destructive to ascarid eggs in the in-vitro experiments.

Aqueous formulations of sodium pentachlorophenate, an alkyl polyamine, and 2-benzyl-4-chlorophenol were prepared, each of which contained two ounces of chemical dissolved in two gallons of water. The eight small pens, numbered in series were each sprayed with two gallons of formulation as follows :

Pens I and V	2 gallons of alkyl polyamine formulation
Pens II and VII	2 gallons of 2-benzyl-4-chlorophenol formulation

* Santobrite—Monsanto Trade Mark.

Pens III and VI 2 gallons of sodium pentachlorophenate formulation
Pens IV and VIII 2 gallons of water only

Immediately following treatment, 21 six-week-old, straight run, white rock chicks were placed in each pen. Eight days later the chickens were killed and the intestines and caeca removed. The larval ascarids were recovered by the hydraulic method of Ackert and Nolf (1929). The intestinal content of each bird was preserved in 5% formalin solution in individual bottles. The faecal material contained in each bottle was washed several times, and the water decanted. The residual solids were examined for ascarid larvae, a portion at a time, in scribed flat bottomed dishes under a stereoscopic microscope. The total number of larvae in each bird was counted and recorded.

Results

Table 1 summarizes the ascarid larval counts from the combined pens which received the four different types of chemical treatment.

Table I

Effect of Chemical Treatment on Ascarid Eggs

Measured indirectly by the degree of ascarid infection which developed in exposed, susceptible chicks.

Combined Pens	*Treatment*	*Total Ascarid Larvae Recovered*	*Mean Avg. Larvae Per Chick*	*Standard Deviation*	*Standard Error*
IV and VIII	Check—Water Only	1146	27·28	16·9	2·61
II and VII	2-Benzyl-4-chlorophenol	1053	25·07	14·63	2·25
I and V	Alkyl polyamine	908	21·6	13·39	2·06
III and VI	Sodium pentachlorophenate	429	10·21	8·15	1·26

Discussion

The marked reduction in larval ascarids recovered from the chicks in the pens treated with sodium pentachlorophenate reflects ovicidal rather than larvicidal activity of the compound, since the ascarid egg does not hatch until it reaches the gut of its host. Further evidence of this fact is the failure of 2-benzyl-4-chlorophenol, a very active larvicide, to reduce the larval counts significantly. Work with larger quantities of more dilute formulations of sodium pentachlorophenate and related compounds may prove more effective since the amount of formulation used with these tests was not sufficient to wet the litter thoroughly.

Although this preliminary work cannot be regarded as an answer to certain types of parasite control, it does bring into prominence a promising approach to the problem. It might permit the practical use of barn lots, pens, poultry houses, dog runs, etc., which had become grossly contaminated with parasite eggs and larvae. This would be even more important if space were limited.

Summary

Chicken pens previously infested with eggs of *Ascaridia lineata* were sprayed with formulations containing sodium pentachlorophenate, an alkyl polyamine, and 2-benzyl-4-chlorophenol.

Six-week-old chickens were placed in the treated pens for eight days, then sacrificed. The larval ascarids recovered from the intestines were counted.

The ovicidal activity of sodium pentachlorophenate was manifest by almost 65% reduction of worm burden which developed in susceptible young chickens. The other compounds investigated appeared to be relatively ineffective.

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Helminth Parasites of Hertfordshire Birds

I.—Trematoda

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This paper is the first of a series which is based on a survey of the helminth parasites of wild birds in Hertfordshire. The survey was carried out over a period of 18 months from the winter of 1954–55 to the summer of 1956, and in all a total of 571 birds, representing 22 species, were examined. The majority of these birds were collected at Winches Farm Field Station, St. Albans.

The only comparable survey of this kind was done by Denton and Byrd (1948, 1951) who were working in North America. Their work however differs in several important points. Their survey was extended over the whole of N. America, was carried out over a period of 16 years, and they examined 700 birds representing 120 different species. This gives a ratio of birds examined : species represented of 6 : 1, as compared to that of the present survey which is 26 : 1.

Practically all the work on bird parasites in this country has been concerned with poultry and game birds. (See Soliman, 1955). The exceptions to this are Lewis and Clapham. Lewis (1926) did a general survey of the helminth parasites of birds in the Aberystwyth area. He only dealt with Trematodes and Nematodes and no descriptions are given in the paper. He also (Lewis, 1926) studied the incidence of gapes in starlings in connection with the transmission of this parasite to other hosts.

Clapham (1940) did some work on the helminth parasites of Corvid birds in the British Isles, and on some of the more common wild birds, but she was chiefly concerned with *Syngamus trachea*. No descriptions are given of the various species she found.

It may be pointed out that as regards British records of helminth parasites found in birds, Nicolls' list (1923) is almost completely compiled from continental reports, and is really a list of the parasites

* Part of a thesis approved by the University of London for the award of the Ph.D. degree.

of birds which may be found in this country. Lewis (1926), Baylis (1928, 1939), and Clapham (1940) are almost the only true British records.

During the survey two particular points were kept in mind. The first was the transmission of parasites by wild birds to domestic stock, and secondly the life cycles of the helminths found. It was felt that before further transmission experiments were carried out it was essential to know a lot more about the helminth fauna of wild birds in a particular region, and its variations over a period of time. From the survey one learns what parasites are found in a particular area, in what hosts, at what time of the year, and the degree of incidence throughout the year.

Trematodes of Hertfordshire Birds

During the survey four species of trematodes were found. The following descriptions are based on the material collected during the survey. It is interesting to note that Clapham (1940), when working at St. Albans, only found some *Brachylaemus* species? which were unidentified. Of the four species described in this paper three are from the family *Dicrocoeliidae*. In Travassos' monograph (1944) on this family there are 25 genera and sub-genera, which total has now been increased by Skrjabin (1952) to 30 genera. There is however some degree of overlapping in supposedly discriminating characters between species and even genera, so that the identification of some material is largely a matter of opinion.

Taxonomic position of the species recorded.

Dicrocoeliidae Odhner, 1910

Dicrocoeliinae Faust, 1927

Lutztrema Travassos, 1941

Lutztrema monenteron Price & McIntosh, 1935

Lyperosomum Looss, 1899

Lyperosomum longicauda Rudolphi, 1809

Dicrocoelioides Dollfus, 1954

Dicrocoelioides petiolatum Railliet, 1900

BRACHYLAEMIDAE Joyeux & Foley, 1930

BRACHYLAEMINAE Joyeux & Foley, 1930

Brachylaemus Dujardin, 1843

Brachylaemus fuscatus (Rudolphi, 1819) var. *nicolli* (Witenberg, 1925)

Lyperosomum Looss, 1899

Lyperosomum longicauda (Rudolphi, 1809) Looss, 1899

Body fusiform, very elongate and rounded at the extremities 10·1 mm. long and 1·2 mm. wide, the greatest width being in the region of the acetabulum. Cuticle thin, smooth, and unarmed. The oral sucker is oval and terminal, 0·34 mm. by 0·44 mm. The pharynx is large and oval, 0·19 mm. by 0·28 mm. There is a short oesophagus, branching into two caeca which run laterally nearly to the posterior end of the body. The ventral sucker is slightly transversely oval, 0·78 mm. by 0·84 mm. The testes are round or nearly so, the anterior being 0·52 by 0·52 mm. and the posterior 0·55 mm. by 0·49 mm. They lie slightly obliquely to each other and are separated by uterine coils. The ovary is smaller than the testes, 0·25 mm. by 0·31 mm. and lies behind and obliquely to the posterior testis. The vitellaria are lateral, composed of closely packed follicles forming a narrow band which runs from the region of the posterior border of the anterior testis to the posterior $\frac{1}{3}$ of the body. They overlie and cover the lateral intestinal caeca. The uterus is a greatly convoluted tube which fills all the posterior region of the body, and passes forward to open by the metraterm. The genital pore, into which the cirrus also opens, is just behind the pharynx. The cirrus is 0·52 mm. long by 0·23 mm. and extends back nearly to the acetabular region. The eggs are dark brown and thick shelled, 32μ by 21·5μ.

Host : *Corvus frugilegus frugilegus* (L).

Location : Gall bladder.

Lyperosomum longicauda was first described as *Distoma longicauda* by Rudolphi (1809), from *Corvus cornix cornix*. In 1819 he described a further parasite from the same host calling it *Distoma macrourum*. Braun (1902) examined and re-described this material and that of

Muehling who had referred to very large eggs. He found the eggs to be of similar size to those of the type species, and declared *Distoma macrourum* to be a synonym of *Lyperosomum longicauda*. In 1899 Looss transferred *longicauda* to his new genus *Lyperosomum*, making it the type species with the following characters : very long body, testes and ovary nearly in the same longitudinal axis, and the vitellaria consisting of numerous small follicles in a long strip on either side of the body.

The chief European records are from *Hieraatus pennatus* by Rudolphi (1819), from *Merula merula merula*, *Sturnus vulgaris vulgaris* and *Anthus trivialis* by Diesing (1850), from *Lanius collurio* by Linstow (1889), from *Corvus corone corone* and *C. frugilegus frugilegus* by Wolffhügel (1900), from *Turdus ericetorum ericetorum* by Baird (1902), from *Garrulus glandarius rufitergum* by Nicoll (1923) and from *Pica pica pica* by Timon-David (1953).

Corvus frugilegus frugilegus is thus a new host record for this country.

Lutztrema Travassos, 1941

Lutztrema monenteron (Price and McIntosh, 1935) Travassos, 1941

Body fusiform, rounded at the extremities, 1·9–4 mm. long and 0·27–0·5 mm. wide, being broadest in the region between the ventral sucker and the vitellaria. Cuticle thin, smooth and unarmed. Oral sucker 0·11–1·15 mm. by 0·09–1·14 mm., subterminal and ventral, with a small dorsal lip-like projection. Pharynx globular or sub-globular, 0·03–0·08 mm. by 0·04–0·08 mm. The oesophagus leads straight into a single intestinal caecum which passes dorsal to the ventral sucker, to the side of the anterior testis, between the two testes, and between the posterior testis and the ovary. It remains dorsal, but runs in a sinuous course, terminating approximately halfway between the end of the vitellaria and posterior extremity of the body. The ventral sucker is strongly muscular with a deep lumen, 0·17–0·3 mm. by 0·12–0·29 mm., and usually occupies two-thirds the width of the body. The distance between the suckers varies from 0·14–0·5 mm., and the relation of their width from 1 : 1·6–2·3. The genital aperature is median and ventral, opening halfway between the two suckers. The cirrus-sac is elongate to flask-shaped, the position depending on the degree of contraction of the pre-acetabular region. The testes are ovoid, usually regular in outline. The anterior testis 0·09–0·3 mm. by 0·17–0·32 mm. is

usually diagonally in front of the posterior one 0·08–0.29 mm. by 0·15–0·38 mm. The ovary is transversely ovoid, 0·08–0·14 mm. by 0·09–0·23 mm. and lies behind the posterior testis and in line with the anterior testis. The distance between the testes and the ovary

Fig. 1.—*Lyperosomum longicauda* from gall bladder of Rook (*Corvus frugilegus*). *Lutztrema monenteron*. Fig. 2.—From gall bladder of Mistlethrush, (*Turdus viscivorus*). Fig. 3.—From gall bladder of Blackbird, (*Turdus merula*).

may vary with the degree of contraction of the specimen. Laurer's canal opens dorsally to the ovary. Mehlis's gland lies behind the ovary and is fairly well developed. The vitellaria are lateral, consisting of fairly large follicles which start just behind the ovary. The follicles tend to meet in the mid line anteriorly, and are usually

more developed on one side than on the other. The uterus, with greatly convoluted descending and ascending limbs fills all the posterior part of the body. The eggs are dark brown 32–36μ by 16–24μ.

Hosts: *Turdus merula merula, T. viscivorus viscivorus, T. pilaris* and *Corvus frugilegus frugilegus*

Location : Gall bladder.

The genus *Lutztrema* was created by Travassos in 1941 for species with an elongate body, ventral sucker considerably larger than the oral sucker, a single fairly long caecum, testes quite close to each other and nearly in tandem, vitellaria composed of a few large follicles behind the ovary and tending to meet in the mid line, and a cirrus opening behind the pharynx. Species of this genus had formerly been placed in the genus *Lyperosomum* chiefly because of the great difficulty in determing the number of caeca, for instance *Lutztrema monenteron* was originally described as *Lyperosomum monenteron*, by Price and McIntosh (1935). There are two species to which the present specimens can be referred. *Lutztrema obliquum* (Travassos, 1917) agrees in every respect except that of the length of the caecum. Travassos, (1941) considered *L. monenteron* to be synonomous with *L. obliquum*, the only differences between them being the length of the caecum and the size of the eggs. Denton and Byrd (1951) agree with this close relationship, but after examining further material report that the caecum always terminates well in advance of the posterior extremity of the body, and that there is a small but constant difference in the size of the eggs. I have examined well over 50 specimens and in these the caecum always terminates some distance from the posterior end of the body, but I am unable to confirm the constant difference in the size of eggs, having found the limits to include the ranges given for both trematodes. I agree with Denton and Byrd that *L. monenteron* be retained as a distinct species, separated from *L. obliquum* on the length of the caecum.

Lutztrema monenteron was described by Price and McIntosh, (1935) from *Erithacus rubecula melophilus* and *Sialia sialis*. In 1940 it was transferred by Strom to the genus *Brachylecithum* and in 1941 to Travassos' newly created genus *Lutztrema*. Ishii, (1942) reported it from *Bonasa umbellus* and *Tyrannus tyrannus*. Denton and Byrd, (1951) re-examined Ishii's material which was in such poor condition that they were unable to confirm the identification. They also recorded the parasite from *Mimus polyglottos* and *Toxostoma rufum*.

	L. monenteron Price & McIntosh (1935)	*L. monenteron* Mettrick (Present paper)	*L. monenteron* Travassos (1917)
Length	1·9–5·2	1·89–4·41	2·3–4·6
Breadth	0·63–0·67	0·26–0·54	0·33–0·55
Oral sucker	0·12–0·17	0·11–0·15 × 0·09–0·14	0·09 × 0·15
V. sucker	0·17–0·32 × 0·2–0·3	0·17–0·3 × 0·12–0·29	0·2 × 0·28
Ant. testis	0·14–0·26 × 0·25–0·46	0·09–0·3 × 0·12–0·29	0·1–0·19 × 0·24–0·3
Post. testis		0·75–0·29 × 0·15–0·38	
Ovary	0·09–0·13 × 0·1–0·22	0·75–0·14 × 0·09–0·23	0·13–0·17 × 0·12–0·29
Eggs	0·036 × 0·016	0·032–0·036 × 0·016–0·024	0·034–0·038 × 0·022–0·024

All measurements are in mm.

The first European records were by Mettrick (1956) who reported it from *Turdus merula merula*, *T. viscivorus viscivorus*, and *Corvus frugilegus frugilegus*. *Turdus pilaris* is therefore a new host record.

Travassos (1944) illustrates some considerable variation in the size, shape, and position of the various organs of *L. obliquum*. This has also been a feature of the material that I collected, considerable variation occurring in specimens from the same bird.

Dicrocoelioides Dollfus, 1954

Dicrocoelioides petiolatum (Railliet, 1900) Dollfus, 1954

Body long and fusiform, rounded at the extremities, 4·3–10·2 mm. long and 0·8–1·6 mm. wide, the greatest width being in the region of the ventral sucker. Cuticle thin, smooth, and unarmed. Oral sucker sub-terminal and ventral 0·18–0·53 mm. by 0·21–0·6 mm. The pharynx is globular 0·75–0·26 mm. by 0·09–0·26 mm. A short oesophagus leads to the bifurcation of the gut, which occurs nearer the pharynx than the ventral sucker. The intestinal caeca are quite thick, lateral and terminate near the posterior end of the body. The ventral sucker is large, 0·45–0·95 mm. by 0·54–0·96 mm. and it has an elliptical opening. The testes vary in shape from round to pear-shaped, lie side by side or slightly obliquely behind the ventral sucker and between the intestinal caeca. The anterior testis, 0·11–0·42 mm. by 0·15–0·5 mm. is usually slightly smaller than the posterior testis, 0·11–0·47 mm. by 0·14–0·59 mm. The two testes are separated from each other and from the ovary by uterine coils. The ovary is smaller than the testes, measuring about 0·15–0·38 mm. by 0·2–0·4 mm. and lies behind the left testis. The vitellaria are lateral, overlying the lateral caeca and run posteriorly from the level of the testes to a little beyond the end of the middle third of the body. They are composed of numerous small follicles, especially at the anterior end. The uterus is a greatly convoluted tube filling all the posterior region of the body and passing forward to open by the metraterm. The genital pore opens a little behind the pharynx. The cirrus does not reach the anterior border of the ventral sucker. The eggs are dark brown in colour and thick shelled, 0·028–0·052 × 0·02–0·028 mm.

Hosts: *Turdus merula merula*, *T. viscivorus viscivorus*, *T. pilaris*, *T. ericetorum ericetorum*, *Sturnus vulgaris vulgaris*, *Corvus*

frugilegus frugilegus, C. modedula spermologus, Garrulus glandarius, and *Prunella modularis.*

Location : Gall bladder.

There are three genera into which the specimens collected could possibly fall i.e. *Conspicuum, Zonorchis,* and *Dicrocoelioides.* Forms in *Conspicuum* are proportionately larger, with their greatest width behind the ovary, and those in *Zonorchis* have acetabular testes, so there remains *Dicrocoelioides* into which the material fits well.

Railliet (1900) very briefly described a trematode from *Garrulus glandarius rufitergum* as *Dicrocoelium petiolatum.* The following year Braun (1901) described a second species from *Thraupis palmarum* as *D. delectans.* In 1902 Braun gave a fuller description of both of them, from which it was seen that the differences between them were not as great as those in the original descriptions. Nicoll (1915) transferred *D. petiolatum* to the genus *Platynosomum* (Looss, 1907), and Travassos (1916) moved *D. delectans* to the same genus. In 1944 *P. petiolatum* was moved by Travassos to the genus *Lyperosomum* Looss, 1899. In 1922 Travassos had described a trematode from *Thraupis palmarum* as *Platynosomum marquesi,* which in 1944 he declared synonymous with *delectans* Braun. Denton and Byrd (1951) suggested that *Zonorchis delectans* be regarded as a synonym for *Lyperosomum* (= *Dicrocoelium*) *petiolatum* and that *Platynosomum delectans P. marquesi,* and *Lyperosomum petiolatum* should all be grouped under the name *Zonorchis petiolatum* (Railliet, 1900) Travassos, 1944. Dollfus (1954), proposed a new genus *Dicrocoelioides* for those forms of moderate width, not very elongate, the greatest width being in front or at the level of the testes, the ventral sucker twice as large as the oral, testes not symmetrical or acetabular, but slightly oblique and side by side. In this new genus he placed *petiolatum* (Railliet, 1900).

Dicrocoelioides petiolatum was first described from *Garrulus glandarius rufitergum* by Railliet (1900). Other European records are for *Pica pica pica* (Timon-David, 1953) and *Passer domesticus domesticus* (Dollfus, 1954). The British records are for *G. glandarius rufitergum, Turdus merula merula,* and *Burhinus oedicnemus oedicnemus* (Baylis, 1939).

The following are therefore new host records : *Sturnus vulgaris vulgaris, Turdus viscivorus viscivorus, T. ericetorum ericetorum, T. pilaris, Corvus frugilegus frugilegus* and *C. monedula spermologus.*

A striking feature of the material collected is the variation in the shape and to a certain extent the position of the testes and the ovary.

Brachylaemus Dujardin, 1843

Brachylaemus fuscatus (Rudolphi, 1819) var. *nicolli* (Witenberg, 1925)

Elongate, cylindrical body, 3·3–4·4 mm. long by 0·6–0·7 mm. wide. Cuticle finely spinous in the anterior region. The oral sucker is sub-terminal, oval, and ventral 0·23–0·27 mm. by 0·23–0·3 mm. The pharynx is large, globular or sub-globular 0·14–0·17 mm. by 0·15–0·18 mm. Oesophagus absent, the two intestinal caeca arising straight from the pharynx, and running to the posterior end of the body. The ventral sucker is a third of the way down the body and is of the same size or slightly larger than the oral sucker, being 0·24–0·27 mm. by 0·27–0·3 mm. The testes are posterior in position, ovoid in shape, and in tandem with the ovary, the anterior being 0·24–0·35 mm. by 0·27–0·39 mm. and the posterior being 0·23–0·29 mm. by 0·28–0·38 mm. The ovary is also ovoid, 0·17–0·21 mm. by 0·2–0·24 mm. and lies between the testes. Mehlis's gland lies to the side of the ovary. The vitellaria are lateral and cover the intestinal caeca on either side. They run from the level or just in front of the posterior border of the ventral sucker to the level of the anterior border of the anterior testis. The uterus is a convoluted tube which fills all the area between the lateral caeca. The ascending limb reaches the intestinal bifurcation and the descending limb opens ventrally by the metraterm, level with or just in front of the anterior border of the anterior testis. The cirrus is elongate 0·38–0·15 mm., and lies slightly to the side of the midline in a longitudinal axis and opens by the genital pore. The eggs are small 24–28 μ by 16–18 μ

Hosts : *Turdus merula merula*, *T. ericetorum ericetorum*, and *Sturnus vulgaris vulgaris*.

Location : Intestine.

In the genus *Brachylaemus* created by Dujardin (1843) there is a considerable overlapping of the characters of the various species in the genus, and the identification is sometimes a matter of personal opinion. It is considered that the species of the genus occurring in birds are distinct from those in mammals but it is now known that

it is possible to obtain adult mammalian species in birds. We will consider two of the bird species :

Brachylaemus fuscatus (Rudolphi, 1819) was described from material found in *Coturnix coturnix*, and re-described by Braun (1902) The oral sucker is larger than the ventral, the vitellaria go a little beyond the posterior border of the ventral sucker, and the

Dicrocoelioides petiolatum. Fig. 4.—From gall bladder of Blackbird, (*Turdus merula*). Fig. 5.—From gall bladder of Mistlethrush (*Turdus viscivorus*). Fig. 6.—*Brachylaemus fuscatus* var. *nicolli* from intestine of Starling (*Sturnus vulgaris*).

eggs are 23μ × 14–18μ. Braun also considered specimens collected from *Columba palumbus* as *B. fuscatus*, in which the ventral sucker is appreciably the smaller and there are spines on the anterior part of the body. Timon-David (1953) has referred to this species specimens he collected from *Pica pica*. Some of his specimens have an oral sucker slightly smaller than the ventral. Thus *B. fuscatus*, *sensu* Timon-David, is seen to have a variable relationship between

the size of the suckers, and other characters must be consideredin deciding this species.

Brachylaemus nicolli (Witenberg, 1925) was described from material from *Passer domesticus*, in which the suckers are unequal the oral being slightly the smaller. This species was created on only two specimens and if a larger number has been examined it might have been seen that the oral sucker was usually a little larger. The other characters used by Witenberg to distinguish *nicolli* from *fuscatus* are not valid and the former species therefore falls as a synonym of *fuscatus*. (Dollfus, 1954). Joyeux, Baer, and Timon-David (1932) after comparing the two species concluded that morphologically they were the same. Dollfus (1954) suggests that *nicolli* be kept as a variety of *fuscatus* for those specimens which have subequal suckers the oral being the same size or slightly smaller than the ventral, unlike the present type species of *fuscatus*. He described some material from *Columba livia livia* under the name *Brachylaemus fuscatus* var. *nicolli*.

	B. fuscatus var. *nicolli* present paper	*B. fuscatus* var. *nicolli* (Witenberg, 1925)
Length	3·3–4·4	4·1–5·14
Breadth	0·6–0·7	0·8 in dia
Oral sucker	0·23–0·27 × 0·23–0·3	0·26–0·3 × 0·22–0·27
Pharynx	0·14–0·17 × 0·15–0·18	0·16 × 0·12
V. sucker	0·24–0·27 × 0·27–0·3	0·26 × 0·3
Ant. testis	0·24–0·35 × 0·27–0·39	0·42 in dia.
Post. testis	0·23–0·29 × 0·28–0·38	
Ovary	0·17–0·21 × 0·2–0·24	0·22 × 0·24
Eggs	24–28μ × 16–18μ	22–33μ × 18μ

All measurements in mm.

B. fuscatus was originally described from *Coturnix coturnix* (Rudolphi, 1819), and in the same year from *Turdus viscivorus* by the same author. The European records are for *Columba livia* (Stossich, 1898), from *Columba palumbus* (Braun, 1902), from *Burhinus oedicnemus* (Andre, 1917), from *Passer domesticus* and *Corone frugilegus* (Witenberg, 1925), from *Crex crex* (Semenow, 1927), and from *Corvus corone* (Markowski, 1933). Also Joyeux, Baer, and Timon-David (1934) obtained experimental infections in *Columba livia* and *Turdus merula*. The only records for this country (Baylis, 1939) are from *Columba palumbus*, *Sturnus vulgaris*, and *Garrulus glandarius*. *Turdus ericetorum ericetorum* is thus a new host record, and *Turdus merula merula* the first record of a natural infection and a new record for this country.

List of parasites and their recorded hosts

Lyperosomum longicauda	†	*Corvus frugilegus* (Rook)
Lutztrema monenteron		*Turdus merula* (Blackbird)
		Turdus viscivorus (Mistlethrush)
	*	*Turdus pilaris* (Fieldfare)
		Turdus ericetorum (Songthrush)
		Corvus frugilegus
Dicrocoelioides petiolatum	*	*Turdus viscivorus*
	*	*Turdus ericetorum*
		Turdus merula
	*	*Turdus pilaris*
	*	*Sturnus vulgaris* (Starling)
	*	*Corvus frugilegus*
	*	*Corvus monedula* (Jackdaw)
		Garrulus glandarius (Jay)
	*	*Prunella modularis* (Hedgesparrow)
Brachylaemus fuscatus	†	*Turdus merula*
	*	*Turdus ericetorum*
	†	*Turdus viscivorus*
		Sturnus vulgaris
		Garrulus glandarius

† New host record for this country. * New host record.

SUMMARY

Re-descriptions are given of the following species :—

1. *Lyperosomum longicauda* (Rudolphi, 1809) Looss, 1899.
2. *Lutztrema monenteron* (Price and McIntosh, 1935) Travassos, 1941.
3. *Dicrocoelioides petiolatum* (Railliet, 1900) Dollfus, 1954.
4. *Brachylaemus fuscatus* (Rudolphi, 1819) var. *nicolli* (Witenberg 1925).

Previous host records for these trematodes are given.

A list is given of the host records made during the survey.

Acknowledgments

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A Redescription of the Nematode *Paraspidodera sellsi* Morgan, 1927 and its Removal to a New Genus, *Morgascaridia*

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Morgan (1927), in describing *Paraspidodera sellsi* from specimens found in a "Wild Pig" in Uganda, expressed the opinion that his new species would probably be found to belong to a distinct genus when fresh material became available for study. With this opinion Lent and Freitas (1939), after an extensive study of *Paraspidodera uncinata* (Rudolphi, 1819), did not agree. More recently Vuylsteke (1956), in reporting a supposed new variety of *P. sellsi* from *Potamochoerus porcus* Linnaeus, 1758 in the Belgian Congo suggested that it was probably not congeneric with *P. uncinata* while Inglis (1957), in defining the family Aspidoderidae treated *P. sellsi* as a species *incertae sedis*.

The condition of Morgan's material was rather bad so that although the structure of the posterior end of the male could be made out satisfactorily, he was unable to study the structure of the head in detail; in consequence reference of the species to *Paraspidodera* was made mainly on the tail characters. In addition, Morgan considered the oesophagus to have a posterior bulb, which suggested heterakid affinities, but, as his figures show, the oesophagus is in fact club-shaped, without a definite posterior bulb and without any of the internal valves so typical of the heterakids. The whole appearance of the oesophagus is much closer to that of the family Ascaridiidae Skrjabin and Mosgovoy, 1953, and to this family I consider the species to belong.

I shall argue later that this family should contain three genera, *Ascaridia* Dujardin, 1845 and *Schneidernema* Travassos, 1927 from both of which *P. sellsi* appears to be sufficiently distinct to warrant the creation of a third genus, *Morgascaridia*, the affinities of which will be discussed more fully after the description of *M. sellsi* which follows.

Morgascaridia sellsi (Morgan, 1927), nov. comb.

Synonymy :

Paraspidodera sellsi Morgan, 1927, *J. Helminth.* **5,** 105–108, Figs. 1–4 ; Inglis, 1957 (species *incertae sedis*), *Proc. zool. Soc. Lond.*, 128, 142.

Paraspidodera sellsi var. *zadi* Vuylsteke, 1956. *Rev. Zool. Bot. Afr.* 53, 456–458, Figs. 36–42.

Type Host :

"Wild Pig", Uganda.

Other Hosts :

Potamochoerus porcus Linnaeus, 1758, Stomach. Manzadi (Zadi-Kakongo), Bas Fleuve. (*P.s. zadi* Vuylsteke, 1956).

Material Studied :

20♂♂, 20♀♀. Syntypes, *Paraspidodera sellsi*. London School of Hygiene and Tropical Medicine, Helminthological Collections. 1♂ here selected Lectotype.

1♂, 3♀♀. *Paraspidodera sellsi* var. *zadi*, Musée Royal du Congo Belge, Tervueren. Reg. Nos. 22109–22112.

Morgan's specimens are, as he pointed out, in rather poor condition but are not so bad that it is impossible to fully determine their structure, including that of the head ; while Vuylsteke's are in a much poorer condition which may explain her failure to note a greater number of caudal papillae and the bluntly spatulate posterior ends of the spicules, this latter character being most distinctive. Morgan gave his measurements as averages and gave no indication of the total range in size of any of the characters, but when his specimens are measured Vuylsteke's variety falls fully within their limits. Thus, as I have been unable to find any morphological characters which show significant differences between the two populations, I consider them to represent one species, so that *P. sellsi* var. *zadi* becomes a synonym of *M. sellsi*.

Description

The head bears three rather small lips, of which the dorsal is markedly smaller than the two ventral. The former lip has a pair of large, double, sessile papillae on its margins while each of the latter carries a prominent finger-like "papilla" lateral in position and a small (? two) sessile papilla ventrally. The finger-like structures are most unusual and are apparently due to the eversion of recessed

amphids. The inner surface of each lip has a flange, developed from the cuticular lining, which projects anterior to the outer lip mass (Fig. 2, f.). This structure was described by both Morgan and Vuylsteke as a tooth, which it certainly resembles when seen in optical section. Due to its being more prominent on the dorsal lip its presence on the ventro-laterals can be easily overlooked.

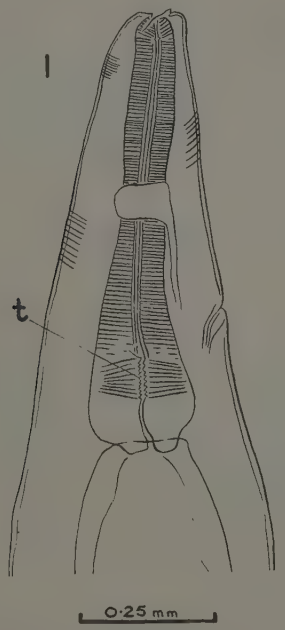


Fig. 1.—*Morgascaridia sellsi*. Anterior end of the body from the side showing the shape of the oesophagus and the arrangement of the small teeth (t) in the posterior part.

The anterior end of the club-shaped oesophagus is modified into a pharynx in which the muscles run anteroradially (Fig. 1), while in the remainder of the oesophagus they are arranged wholly radially. The posterior, clubbed part of the oesophagus contains three sets of small teeth (Fig. 1., t) which are supplied with special muscles, while the oesophageal lumen is not developed into radial tubes. The nerve ring and the excretory pore are both anterior to the posterior end of the oesophagus.

In the male the tail is long and evenly pointed with a distinct terminal spike. It bears a circular pre-cloacal sucker with a definite cuticular rim, and a varying number of small sessile papillae, the maximum number of which appears to be twenty two pairs, but the variation may be only apparent due to the poor state of the specimens. The distribution of the papillae is most easily understood by reference to Figs. 4 and 5. The spicules are equal and identical with bluntly spatulate posterior ends when viewed laterally (Fig. 5) and are strongly cupped anteriorly for the reception of the spicular muscles (Fig. 3). The gubernaculum is triangular in plan and is flat, with a swollen anterior end when viewed from the lateral aspect. The so called "Telamon" described by Morgan appears to have been suggested by a ridge on the dorsal surface of the gubernaculum which can be seen in some of the specimens when they are studied from certain angles.

Morgascaridia sellsi. Measurements in mm.

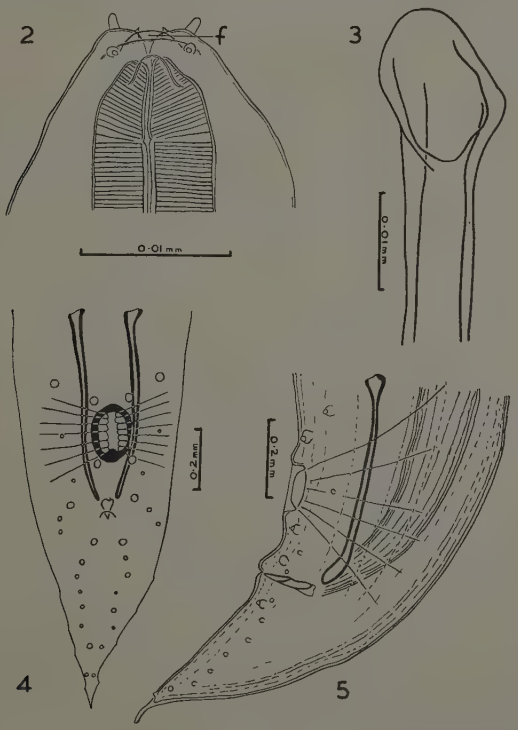
	Male	Female
Length of body	11·0–18·5	15·0–21·0
Breadth of body	0·52–0·76	0·63–0·92
Diameter of head	0·082–0·097	0·089–0·098
Length of pharynx	0·041–0·053	0·043–0·056
Length of oesophagus	0·62–0·79	0·64–0·83
Breadth of oesophagus	0·14–0·21	0·16–0·22
Nerve ring from anterior end	0·31–0·39	0·34–0·41
Excretory pore from anterior end ...	0·38–0·47	0·40–0·48
Diameter of precloacal sucker	0·16–0·23	—
Distance from sucker to cloaca ...	0·17–0·22	—
Length of spicules	0·56–0·71	—
Length of gubernaculum	0·17–0·24	—
Vulva from anterior end	—	7·0–10·2
Length of tail	0·51–0·59	0·71–0·74
Length of terminal spike	0·046–0·056	—

In the female the tail is fairly short and narrows evenly to a sharp point. The vulva opens into a short vagina which loops backwards and continues posteriorly as a wider common uterine trunk for 3·4–4·2 mm. before splitting into two uterine branches, both of which loop forward. The eggs, which are embryonate *in utero*, are thick-shelled and the largest measures 0·085 mm. by 0·057 mm.

Systematic Discussion

The family Aspidoderidae, to which the genus *Paraspidodera* belongs, is characterized by a long, narrow oesophagus with a

distinct, valvulated posterior bulb, a thickening of the cuticle of the head to form a cephalic cap, an inner cuticular flange on the square lips which does not project anterior to the main lip-mass, lateral lobes linking the lips one to another, small teeth at the anterior end of the pharynx and a markedly small pre-cloacal sucker (see



Morgascaridia sellsi. Fig. 2.—Dorsal view of the head showing the anterior flange of the lips (f) and the arrangement of the muscles at the anterior end of the oesophagus. Fig. 3.—Detail of the anterior end of a spicule. Fig. 4. —Ventral view of the male tail. Fig. 5.—Lateral view of the male tail.

Inglis, 1957). The species redescribed above has none of these characters but possesses the large, prominent, circular pre-cloacal sucker and club-shaped, non-valvulated oesophagus typical of the family Ascaridiidae. To this family López-Neyra (1947) (considered a subfamily by that author) referred two genera—*Ascaridia* and

**Schneidernema*. *Ascaridia* has no gubernaculum and has well developed lips with elaborate pulps. In *Schneidernema* the lips are reduced, with a complex arrangement of teeth on their inner surfaces and the excretory pore is post-oesophageal in position. The species under consideration, although an ascaridiide, differs from both these genera and a new genus is accordingly proposed for it, with the following diagnosis :

Morgascaridia gen. nov.

Ascaridiidae : head with three reduced, but distinct, lips each of which bears an anterior cuticular flange projecting beyond the main lip mass ; no elaborations of the lip pulp ; a finger-like projection on each ventral lip, due apparently to the eversion of the amphids ; an anterior pharyngeal modification of the oesophagus present ; oesophagus club-shaped with a series of small teeth posteriorly ; excretory pore anterior to the posterior end of the oesophagus.

Male : spicules equal and identical ; a gubernaculum present.

Female : vulva about middle of body ; eggs thick-shelled ; tail short and evenly pointed.

Type Species : *Morgascaridia sellsi* (Morgan, 1927).

- *Morgascaridia* is here referred to the family Ascaridiidae, which is considered to be constituted with the same genera as were referred by López-Neyra (1947) to the subfamily Ascaridiinae. Since then, Freitas (1956) has introduced a new family, Schneidernematidae, and a new subfamily, Schneidernematinae, for the genus *Schneidernema*. This appears to be excessive and is an expression of the lack of information available in the literature, on a study of which Freitas based his conclusions, on *Schneidernema retusa* rather than a result of an analysis of its structural characters. More recently Chabaud (1957) has referred the subfamily Schneidernematinae to the family Heterakidae. This action is unacceptable : the family Heterakidae, even when the family Aspidoderidae is included as a subfamily, is a homogeneous morphological group characterized

* The genus *Schneidernema* was erected by Travassos (1927) for *Ascaris retusa* Rudolphi, 1819 (1926—*Schneideria* preoccupied ; 1927—*Schneidernema*) a species which has only been reported on three occasions, by Rudolphi (1819), Travassos, (1926) and Araujo (1940). I have been able to study the type material of this species, one male and one female specimen in the collections of the Zoological Museum, Berlin (Cat. No. 398) and, although they are in extremely poor condition, it is possible to be sure that they are conspecific with those described by Travassos.

by three distinct lips, an oesophagus with a marked posterior bulb which contains a well developed valvular apparatus, and well developed marginal tubes at the ends of the radii, tubes into which project a series of paired valvular structures derived from the cuticular lining of the radii. These structures give the oesophagus of the Heterakidae its typical doubled appearance. None of these characters are present in *S. retusa* and the only character in which it resembles the heterakids is in the presence of a circular pre-cloacal sucker. The value of the marginal tubes in the oesophagus as a systematic character is supported by their occurrence in many other what may best be described as"Oxyurid" families (e.g. Subuluridae, Kathlaniidae, Oxyuridae, Dubioxyuridae) morphologically close to the Heterakidae; but they never occur in the Ascaridoidea. On this character alone I would consider *Schneidernema* distinct from the other genera referred to the family Heterakidae by Chabaud.

It is of course impossible to invoke Chabaud's "biological" criteria as expressed in the life history of *S. retusa* since this is completely unknown and Chabaud must have referred it to the family Heterakidae on morphological characters. As a corollary, the systematic position of both *Schneidernema* and *Morgascaridia* must be assessed from a consideration of their morphology; this suggests that both genera are related more closely to *Ascaridia* than to the Heterakidae. I, therefore, here consider the family Ascaridiidae to contain the three genera *Ascaridia*, *Schneidernema* and *Morgascaridia* and leave it provisionally with no groups higher than genera.

In referring the family Ascaridiidae to the superfamily Heterakoidea Chabaud (1957) appears to have assumed that while parallel, or convergent, evolution in morphology is possible such an eventuality does not apply to life histories. There is, of course, always the possibility of the same form of life history being developed in parallel lines of evolution as there is of the same morphological modification being developed. I can see no reason to consider life histories as *a priori* more "biological" than similarities or differences in morphology and would, therefore prefer to consider the family Ascaridiidae a member of the Ascaridoidea, with the members of which it appears to have more in common, than a member of the Heterakoidea.

Acknowledgments

I wish to express my thanks to Prof. J. J. C. Buckley, London School of Hygiene and Tropical Medicine; to the late Dr. E. Dartevelle, Musée Royal du Congo Belge, Tervuren and to Dr. G.

Hartwich, Zoological Museum, Berlin for the loan of the material on which this study is based. Also to Dr. H. W. Parker, British Museum (Natural History), for reading this paper prior to publication.

Summary

1. A new genus *Morgascaridia* is proposed for *Paraspidodera sellsi* Morgan, 1927, which is redescribed.

2. The systematic position of the new genus, and of the genus *Schneidernema*, is discussed and it is suggested that both should be referred to the family Ascaridiidae.

3. The systematic position of the family Ascaridiidae is considered and it is believed to show greatest resemblances to the families placed by Chabaud in the superfamily Ascaridoidea, and is accordingly referred to that superfamily.

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On *Wuchereria patei* n.sp. from the Lymphatics of Cats, Dogs and Genet Cats on Pate Island, Kenya

By J. J. C. Buckley, G. S. Nelson and R. B. Heisch

The discovery of sheathed microfilariae resembling those of *Wuchereria malayi* in the blood of domestic cats and dogs on Pate Island (=Patta Is., Patte Is.) was recorded by Nelson and Heisch in 1957. Since then similar microfilariae have been found in the blood of Genet Cats (*Genetta tigrina*) which are common on the island where they are regarded as a pest because they steal chickens.

The incidence of the microfilarial infection in cats was 14 positive of 25 examined (56%); in dogs, two positive of 5 examined; in Genet Cats, 3 positive of 7 examined.

The microfilariae are very similar to those of *W. malayi*; the only constant difference is the length of the cephalic space which averages 4·8μ as compared with 6·9μ in *W. malayi* (Feng, 1933).

Adult worms, the parent forms of the sheathed microfilariae, were recovered from the lymphatic system of 5 cats, 2 dogs and one Genet Cat. They are described herein as a new species, *W. patei*.

The numbers of worms and the glands or vessels in which some of these were found are indicated in Table I. Owing to the difficulty of searching for and finding adult worms the figures in the Table cannot be taken as representing the actual number present in each animal; others may have been present which were not detected. The method of searching for adult worms was that used and described by Buckley and Edeson (1956) in Malaya. The specimens were cleared and mounted in pure glycerine.

Description

The Female

The principal measurements are as follows: *Length*, 34·5–50·7 mm. (for mean measurements see Table II); *breadth* (maximum), 135–190μ; *oesophagus*, 840–1150μ long; *vulva* (from anterior end), 630–920μ; *tail*, 150–230μ long; *diameter of head bulb*, 40–45μ, dorso-ventrally.

The Male

Length, 14–25·4 mm.; *breadth*, 75–100μ; *left spicule*, 255–295μ long; *right spicule*, 110–130μ long; *spicule ratio*, 2·25–2·7 : 1; *tail*, 140–180μ long; *diameter of head bulb*, 28–40μ, dorso-ventrally.

TABLE I

Numbers and habitats of adult *W. patei* n.sp. recovered from cats, dogs and Genet Cat

Glands	Popliteal	Inguinal	Epitrochlear	Axillary	Cervical	Abdominal	Thoracic
Cat No. 7	1♂, 1♀				1♂, 1♀		
Cat No. 9					2♂, 2♀	1♂, 1♀	
Cat No. 11	1♀				2♂, 1♀		
Cat No. 12		5♂, 3♀		+*		+*	
Cat No. 13	1♂	+*		5♀	2♂, 1♀		1♀
Dog No. 1	3♂, 6♀*		8♂, 6♀				
Dog No. 2	+*		+*				
Genet Cat	1♂	1♀					

*Total not counted ; some removed with glands or vessels for sectioning.

TABLE II

	W. patei n.sp. Means of 12 specimens (6♀, 6♂) from dog.	*W. patei* n.sp. Means of 8 specimens (4♀, 4♂) from cat.	*W. malayi*? of Buckley & Edeson 1956, from monkey	*W. malayi*? of Buckley & Edeson 1956, from cat.	*W. pahangi* Buckley & Edeson 1956, from dog and cat.
FEMALE					
Length	43 mm.	39 mm.	48·2 mm.	—	40 mm.
Breadth	170	158	148	135	100
Oesophagus	1010	1022	1073	1178	817
*Vulva	753	757	690	570	470
Tail	198	180	185	—	147
†Head diam.	41·5	40	36	—	36
MALE					
Length	22·3 mm.	18·9 mm.	18·3 mm.	22·3 mm.	15·1 mm.
Breadth	93	75	75	80	75
Oesophagus	935	888	944	900	852
Left spicule	283	270	342	393	208
Right spicule	119	116	106	123	83
Spicule ratio	2·4 : 1	2·25 : 1	3·3 : 1	3·1 : 1	2·5 : 1
Tail	159	158	142	153	121
†Head diam.	34	33	28	—	24

*Distance from anterior extremity. †Measured dorso-ventrally.
(All measurements in μ unless otherwise stated.)

Relationships

W. patei n.sp. belongs to the "*W. malayi*" group of filarioid nematodes which are characterized mainly (and differentiated from the "*W. bancrofti*" type) by their microfilariae which possess 2 distinct tail nuclei, one terminal and one sub-terminal, and by the presence of only 5 pairs of adanal papillae in the adult male and a well-developed centre section in the left spicule.

Adult worms of the "*W. malayi*" group have been described from man by Rao and Maplestone (1940) and Bonne *et al.* (1941) ; from a monkey and from cats (*W. malayi?*) and from a dog, a cat and a Slow Loris (*W. pahangi*) by Buckley and Edeson (1956). The new species from Kenya needs to be differentiated from these.

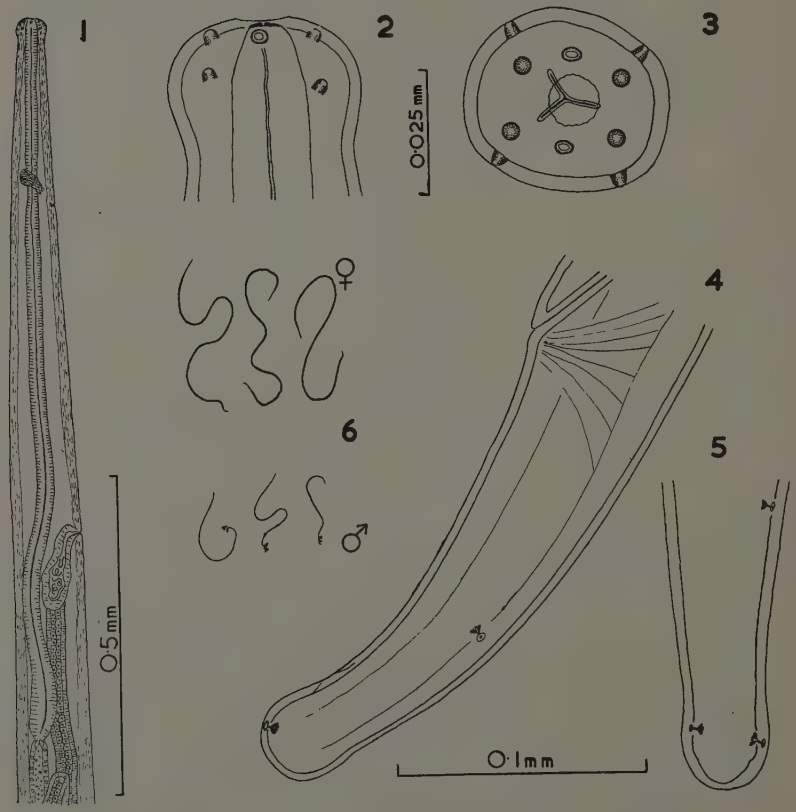
Comparison between *W. patei* n.sp. and *W. pahangi* Buckley and Edeson, 1956.

The male of *W. patei* differs from that of *W. pahangi* in the left spicule which in the former species has a spatulate tip and a cup-like expansion at its proximal extremity (Fig. 7). Dimensional differences occur especially in the lengths of the spicules, the spicule ratio and the length of the tail.

The female of *W. patei* differs from that of *W. pahangi* in measurements only, e.g. body width, head-bulb, oesophagus, tail and distance of the vulva from the anterior extremity. In the tail region the cuticle is either quite smooth or possesses much reduced inconspicuous tubercles. These were originally stated as being absent in *W. pahangi* but subsequent examination of further material has shown that this species also may possess very inconspicuous tubercles in the tail region.

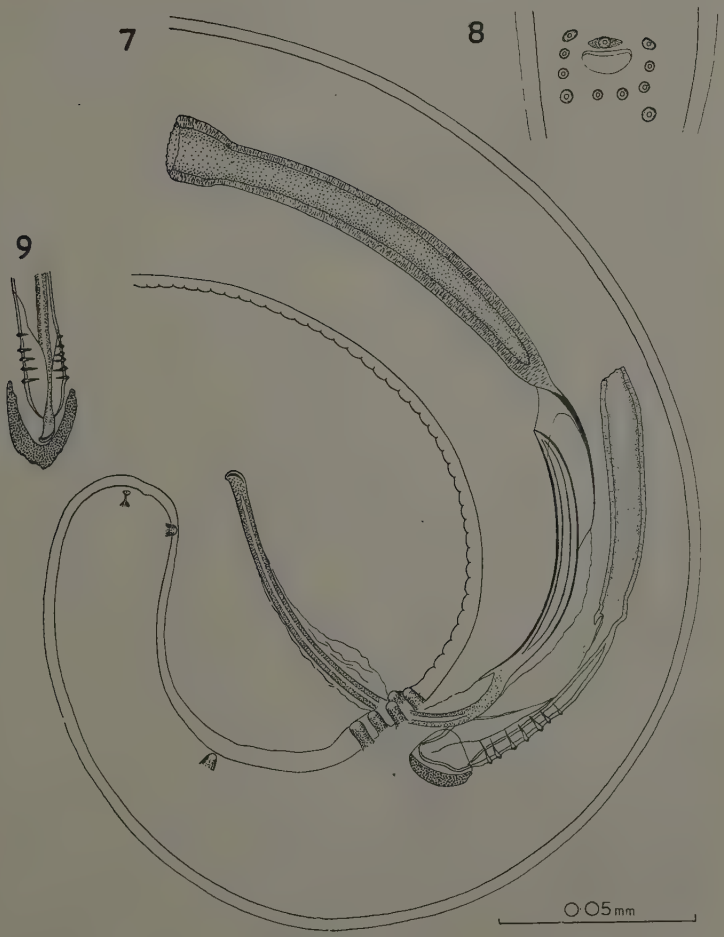
Comparison between *W. patei* n.sp. and *W. malayi?* of Buckley and Edeson (1956).

The male of *W. patei* is not so easily differentiated from the male specimens found by Buckley and Edeson in a monkey (*Macaca irus*) and in cats and identified by them tentatively as *W. malayi* (Brug, 1927), since both forms possess the spatulate tip to the left spicule. The male of *W. patei* can be differentiated, however, by the smaller length of the left spicule (less than 300μ) which in the others is greater than 300μ ; and by spicule ratio which is less in *W. patei*. The cup-like expansion at the proximal end of the left spicule in *W. patei* also helps to differentiate it.



Wuchereria patei n.sp.

Fig. 1.—Anterior extremity of a female, lateral view. Fig. 2.—Head bulb, lateral view. Fig. 3.—End-on view of head. Fig. 4.—Lateral view of female tail. Fig. 5.—Ventral view of female tail to show a pair of terminal phasmids and an unpaired phasmid anterior to them on the left side. Fig. 6.—Adult worms, actual size.



Wuchereria patei n.sp.

Fig. 7.—Tail of male, lateral view. Fig. 8.—Ano-genital region of a male, ventral view. Fig. 9.—Ventral view of distal extremities of the two spicules, and the accessory piece.

The female of *W. patei* differs from the other specimens under discussion notably in the absence or inconspicuous nature of the cuticular tubercles in the tail region.

Comparison between *W. patei* n.sp. and the specimens from man described by Rao and Maplestone (1940) and by Bonne *et al.* (1941).

As with the previous forms from monkey and cat, *W. patei* can be differentiated from the specimens from man by the smaller length of the left spicule which is 350μ long according to Rao and Maplestone and 360μ long according to Bonne *et al.*

Further Observations on Adult Morphology in *W. patei* and in the Related Species from Malayan Animals.

The right spicule. In the description of *Wuchereria* sp. (*malayi?*) by Buckley and Edeson (1956) it was stated (p.8) that the right spicule terminates "in a short cylindrical part with a corrugated surface, through which the left spicule runs". This description was based on a lateral view only of the spicule. By good fortune it has since been possible to obtain a ventral view of the right spicule of *W. patei* (Fig. 9, present paper) from which it is apparent that the terminal part is not completely cylindrical but is open longitudinally on its ventral aspect. This is also apparent sometimes in specimens which have both spicules extruded, when the delicate membrane of the left spicule may be seen to be *outside* the spicule though still attached to that part of the left spicule which is still inside it.

The caudal papillae in the male. In the new species the adanal papillae have the same general arrangement and number as those in the Malayan species from animals, i.e. four pairs of laterals and one pair immediately postanal. In the description of the Malayan species (1956, p.4) it was noted that "Just in front of the anus is a prominence which possibly represents an unpaired papilla". A ventral view of this prominence in *W. patei* (Fig. 8, present paper) has confirmed that there is in fact a large preanal papilla which arises in the centre of a transverse prominence about 8μ long.

Between the adanal group of papillae and the tip of the tail, there is usually (as in the Malayan species) a pair of lateral papillae whose position is variable and sometimes asymmetrical.

At the tip of the male tail there is at least one pair of papillae and one or more phasmids appear to be present.

As was noted in the description of the Malayan species, the papillae in this region are difficult to determine with accuracy; their differentiation from phasmids is also a very difficult matter, hence the illustration of the tip of the tail (Fig. 7) should be regarded as semi-diagrammatic.

Phasmids in the tail of the female. In the new species there is a pair of phasmids at the tip of the tail and at a variable distance between them and the anus there is a single sub-dorsal phasmid situated to the left of the dorsal line (Figs. 4 and 5, present paper). Re-examination of the Malayan species has confirmed that these phasmids are also present in the same position in the female tail of these species.

The oral papillae. In the new species and in the two Malayan species there are ten papillae in two groups of 6 and 4 respectively (Figs. 2 and 3, present paper). Careful examination of the lateral pair comprising the anterior group of these papillae suggests that they may in reality be amphids. This would conform with the presence of amphids in this position in other genera of filarioid nematodes.

A Note on *Filaria ochmanni* Fülleborn, 1908.

The finding, by Nelson and Heisch (1957) of *sheathed* microfilaria in the blood of domestic cats is the first record of this kind from Africa. The first record from Africa of a sheathed microfilaria in the blood of a dog, however, was made 50 years ago by Fülleborn who described it briefly and named it *Filaria ochmanni*; its length was given as 320μ. The photograph accompanying the description shows two microfilariae, one with and one without a sheath. Railliet, Henri and Langeron (1912) thought that these microfilariae belong to *Dirofilaria repens* but the presence of a sheath excludes this possibility. On the other hand the illustration, although not very clear, suggests that it might be one of the "*malayi*" group of microfilariae. With this possibility in mind, blood specimens from 70 dogs from Dar-es-Salaam (whence Fülleborn's specimen came) were examined recently for the presence of sheathed microfilariae, but none were found; nor were they found in the blood of 20 dogs and 3 cats examined at Zanzibar and 17 dogs and 16 cats examined on Pemba Island. So that, for the present, *F. ochmanni* cannot be classified with certainty. Moreover, re-examination of Fülleborn's material is now impossible as the blood films from which he described *F. ochmanni* have been lost. (We are indebted to Dr. W. Minning of the Tropeninstitut, Hamburg, for kindly supplying us with this information.)

Summary

1. A new species of *Wuchereria* is described, from the lymphatic systems of dogs, cats and Genet Cats (*Genetta tigrina*) on Pate Island off the Kenya coast. It is named *W. patei* after the island on which it was first discovered.

2. The new species belongs to the "*W. malayi*" group which are characterized in the microfilarial stage by the presence of one terminal and one sub-terminal nucleus in the tail ; and in the adults by the presence of only 5 pairs of adanal papillae in the male and by the well-developed centre section in the left spicule.

Acknowledgments

The authors are indebted to Dr. Clyde and the Director of Veterinary Services for supplying blood slides from dogs in Tanganyika ; to Mr. Bryant and Dr. Barton for their co-operation in helping us to examine cats and dogs at Zanzibar ; and to Dr. Cunningham for a similar service on Pemba Island. We wish also to thank Mr. Bush for the photomicrographs.

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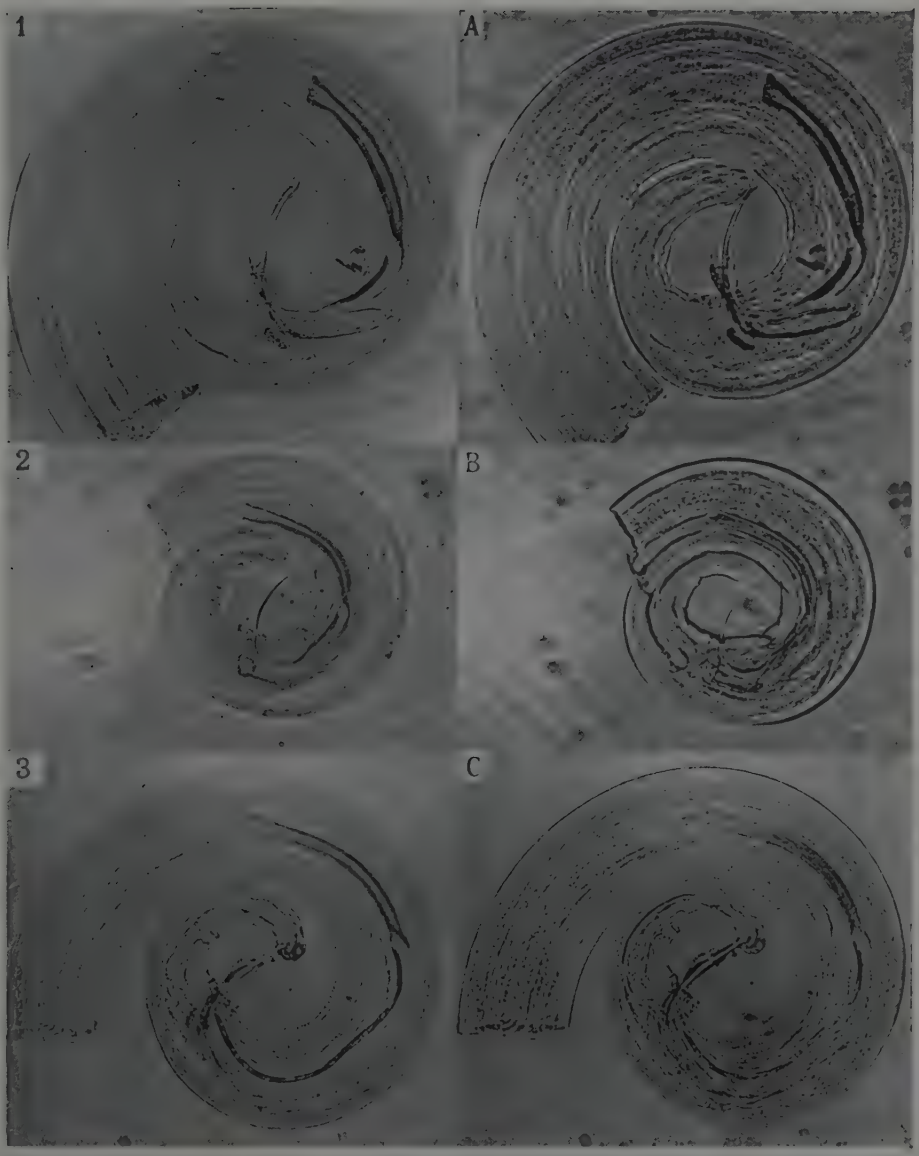

PLATE I

Fig. 1.—*Wuchereria patei* n.sp., male tail. Fig. 2.—*W. pahangi*, male tail.
Fig. 3.—*W. malayi*, male tail.

A, B and C are the same specimens as 1, 2 and 3 respectively, photographed at a slightly different focus.

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On *Euparadistomum heischi* n.sp. from the Liver of a Domestic Cat on Pate Island, Kenya, and a New Sub-family Euparadistominae (Dicrocoeliidae)

By J. J. C. Buckley, D.Sc. and Yeh Liang-Sheng, Ph.D.

Department of Parasitology
London School of Hygiene and Tropical Medicine

During routine examination of lymphatic vessels and glands of domestic cats from Pate Island for specimens of *Wuchereria patei* described elsewhere in this Journal by Buckley, Nelson and Heisch (1958), the opportunity was taken of searching other organs for helminth parasites, which resulted in the discovery of the trematodes which are described herein. Of eight cats examined, one only was found harbouring these helminths, which were present in the gall bladder and numbered fifteen in all.

Description

The shape of the body resembles that of *Eurytrema* in being flat, broad and attenuated at both extremities. It has a length of 4·5–6·5 mm. and a maximum breadth of 2·5–3·4 mm. The cuticle is smooth. The ventral sucker is almost centrally placed and has a diameter of 0·47–0·73 mm. It is generally slightly larger than the oral sucker, although in some specimens it may even be smaller. The subterminal oral sucker measures 0·38–0·56 mm. across. A prepharynx is absent ; the pharynx is about 0·2 mm. in length while the relatively short oesophagus varies from 0·24–0·44 mm. in length. The caeca do not quite reach the caudal end of the worm.

The large testes, 0·51–0·84 mm. in diameter, are intercaecal and symmetrically placed immediately anterior to the ventral sucker. They are generally oval with smooth borders, although in an elongated worm they too become unduly elongated or may even have wavy borders. The oval-shaped cirrus-sac is about 0·36–0·49 mm. in length and contains the seminal vesicle and protrusible cirrus.

The spherical ovary, 0·31–0·47 mm. in diameter is situated at the posterior border of the ventral sucker. The Laurer's canal proceeds postero-dorsally to open on the dorsal surface. The oviduct arises from the anterior part of the ovary and is soon joined by a large spherical seminal receptacle and the short duct from the relatively large vitelline reservoir. The ootype is lightly invested by Mehlis' gland. The follicular vitellaria occupy the middle third of the lateral field, usually divided into an anterior and a posterior group.

The uterus takes a sinuous course to fill much of the worm (Fig. 3). The course it follows is difficult to eludicate, but it appears that as soon as it leaves the ootype, it descends in a tortuous manner along the right side, then ascends close to the ovary to descend again along the left side. From here it goes diagonally across and traverses the ovary, turns at the anterior margin of the ovary and then follows a strictly median course between the two testes until the anterior border of the testes is reached. From here it takes a sharp right turn forming coils along the right lateral field as far anterior as the oral sucker ; from here it descends to the level of the ovary, ascends again as far as the anterior border of the testes and crosses to the left side to make similar coils. After filling the anterior left lateral field, the uterus soon becomes a small narrow tube and proceeds towards the median line, then cephalad to open independently immediately anterior to the male opening. The oval operculated eggs measure 50–63 by 29–33 microns.

The excretory pore is subterminal. The bladder is Y-shaped with a long narrow stem reaching as far as the ovary before the two branches are received.

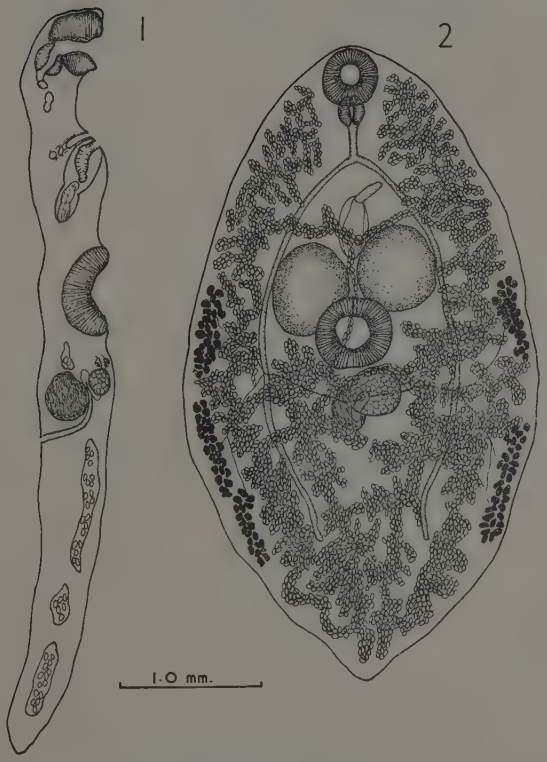
The new species is named as a tribute to Dr. R. B. Heisch whose investigations on Pate Island have led to some very interesting helminthological discoveries.

Host : Domestic cat.

Location : Gall bladder.

Locality : Pate Island.

Types : In the helminthological collection, London School of Hygiene and Tropical Medicine.



Euparadistomum heischi n.sp.

Fig. 1.—Sagittal section. Fig. 2.—Ventral view of whole mount.

Relationships

Before giving reasons for describing these helminths as a new species, it is necessary to give a brief account of the genus *Euparadistomum* Tubangui, 1931 (into which the present species clearly falls) and of the species it contains, or ought to contain, in the writers' opinion.

Tubangui erected this genus for *E. varani* Tubangui, 1931, seven specimens of which were collected from the gall-bladder of a Chick-eating Lizard (*Varanus salvator*) in Luzon, Philippines. Later, Gogate (1939) described a second species, *E. cerivoulae*, from the intestine of a bat, *Cerivoula picta* from Burma.

Sandground (1937) described a third species, closely related to the previous two, of whose existence he was apparently unaware, and placed it in the genus *Dictyonograptus* Travassos, 1919 (a most unsuitable choice) naming it *D. pipistrelli*, as it came from the gall-bladder of a bat, *Pipistrellus nana* (Belgian Congo.)

The fourth species was described by Jansen (1941) who went to the trouble of erecting a new genus for it, *Evandrocotyle*, being unaware, as Sandground was, that there existed already the good genus *Euparadistomum* awaiting its reception. Jansen's specimens came from the bile-duct and gall-bladder of the Philander Opossum, *Philander* [*Caluromys*] *philander*, (Brazil) and were named by him *Evandrocotyle paraense*. Noting its close resemblance to *D. pipistrelli* Sandground, 1937, he removed the latter from *Dictyonograptus* and put it in his new genus *Evandrocotyle*.

This rather complicated situation was straightened out by Travassos in 1944 when he obliterated Jansen's genus *Evandrocotyle* as a synonym of *Euparadistomum* and listed the following species in *Euparadistomum* :

E. varani Tubangui, 1931

E. pipistrelli (Sandground, 1937) Travassos, 1944

E. cerivoulae Gogate, 1939

**E. zonouri* (Malan, 1939) Travassos, 1944

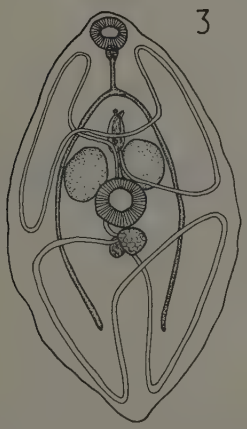
E. paraense (Jansen, 1941) Travassos, 1944

**?*E. koschewnikowi* (Skrjabin and Massino, 1925) Travassos, 1944.

*On account of the restricted uterine coils, this species does not belong to *Euparadistomum*.

**This species which was listed with a question mark, was moved in the same year to a new genus *Stromitrema* by Skrjabin and Evranova (1944).

The situation, however, was again confused by Chatterji in 1952 by his non-acceptance of the genus *Euparadistomum*, which he considered to be a synonym of *Platynotrema* Nicoll, 1914. This opinion was put forward in a paper describing a new species of *Platynotrema*, *P. upapai* n.sp. (=*lapsus calami* for *P. upupai*) from the gall-bladder of *Upupa epops orientalis* or Indian Hoopoe. Chatterji considered that the extension of the uterus throughout the body



Euparadistomum heischi n.sp.

Fig. 3.—Schematic presentation of course of uterus.

as in *Euparadistomum* was not sufficient to separate this genus from *Platynotrema*, in which the uterus is confined to the post-acetabular region. We reject this opinion as untenable, especially in view of the existence of two species which Chatterji omitted to mention, *E. paraense* and *E. pipistrelli*, and we transfer his species *upu* [*a*] *pai* to the genus *Euparadistomum* which we regard as a perfectly valid genus.

By this reckoning, there are now five species of *Euparadistomum* in the literature from which our new species, *E. heischi*, must be differentiated. These are as follows :—

E. varani Tubangui, 1931. Seven specimens from gall-bladder, *Varanus salvator*, Philippines.

E. cerivoulae Gogate, 1939. One specimen from intestine, *Cerivoula picta*, Burma.

E. pipistrelli (Sandground, 1937). One specimen from gall-bladder *Pipistrellus nana*, Belgian Congo.

E. paraense (Jansen, 1941). Four specimens from gall-bladder, *Philander philander*, Brazil.

E. upupai (Chatterji, 1952). Two specimens from gall-bladder, *Upupa epops*, India.

E. heischi n.sp., fifteen specimens of which were collected from the gall-bladder of a domestic cat, Kenya, Africa, can easily be differentiated from all these species by the size of the testes which have about the same diameter as that of the ventral sucker. In the species previously described the diameter of the testes is about half that of the ventral sucker.

Discussion

The six species occupying the genus *Euparadistomum* exhibit a wide variety of hosts and have a wide geographical range ; and with one exception, *E. cerivoulae*, which was probably an aberrant specimen in the *intestine* of the host, they occur in the gall-bladder or biliary passages. Doubtless other species of this interesting genus will be discovered in due course.

Euparadistomum Tubangui, 1931 and *Stromitrema* Skrjabin and Evranova, 1944 are unique in the Dicrocoeliidae in that in all the species of these two genera, the uterus extends forward anterior to the acetabulum forming loops on each side which may reach to the oral sucker. (In at least one species, *E. heischi*, the course of the uterus has been followed and has been found to descend and ascend several times before opening to the exterior.) In other genera the uterus is post-acetabular in position and takes a simple descending and

ascending course. On account of the pre-acetabular distribution of the uterus in these two genera, we propose to erect a new subfamily for them as follows :—

Euparadistominae n. subf.

Diagnosis : Same as family. Uterus descending and ascending several times both posterior and anterior to ventral sucker.

Type genus : *Euparadistomum* Tubangui, 1931
Syn. *Evandrocotyle* Jansen, 1941.

Other genera : *Stromitrema* Skrjabin and Evanova, 1944.

Travassos (1944) recognised three subfamilies, *viz.*, Dicrocoeliinae Looss, 1899, Infidinae Travassos, 1944 and Mesocoeliinae Dollfus, 1929. He also appears to have overlooked Dollfus (1933) who listed *Mesocoelium americanum* Harwood, 1932 under Mesocoeliidae without any note to show the erection of a new family. Dollfus later confirmed the family (1950). Skrjabin and Evranova (1952), following previous workers, recognised only Dicrocoeliinae and Infidinae.

The subfamily Dicrocoeliinae has a seminal receptacle and median genital pore.

The subfamily Infidinae does not have a seminal receptacle while the genital pore is submedian.

The subfamily Euparadistominae has a seminal receptacle, a median genital pore and the uterus extending to the oral sucker.

A key to the subfamilies of Dicrocoeliidae.

1. Uterus descending and ascending both posterior and anterior to ventral sucker.....*Euparadistominae* n. subf.

— Uterus descending and ascending posterior to ventral sucker only 2

2. Seminal receptacle present, genital pore median ....*Dicrocoeliinae* Looss, 1899

— Seminal receptacle absent, genital pore submedian..... ..... *Infidinae* Travassos, 1944

Summary

Euparadistomum heischi n.sp., the sixth species in the genus, was recovered from a domestic cat on Pate Island, Kenya. In the Dicrocoeliidae, a new subfamily Euparadistominae is proposed for two genera, *Euparadistomum* Tubangui, 1931 and *Stromitrema* Skrjabin and Evranova, 1944.

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Journal of Helminthology, Vol. XXXII, Nos. 1/2, 1958, pp. 89–92.

On a New Bursate Nematode, *Longistriata kenyae* sp. nov. from the House Rat, *Rattus rattus kijabius* in Kenya and the Erection of a New Genus *Longistrioides*

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One male and four females were recovered from the anterior part of the intestine of the house rat, *Rattus rattus kijabius* in Kenya. They were found to belong to an undescribed species of trichostrongyloid for which the name *Longistriata* (*Brevispiculoides*) *kenyae* is proposed. I wish to thank my friend Mr. W. F. J. McClelland for the material, and Professor J. J. C. Buckley for his interest in the work.

Heligmosomidae Cram, 1927

Longistriata Schulz, 1926

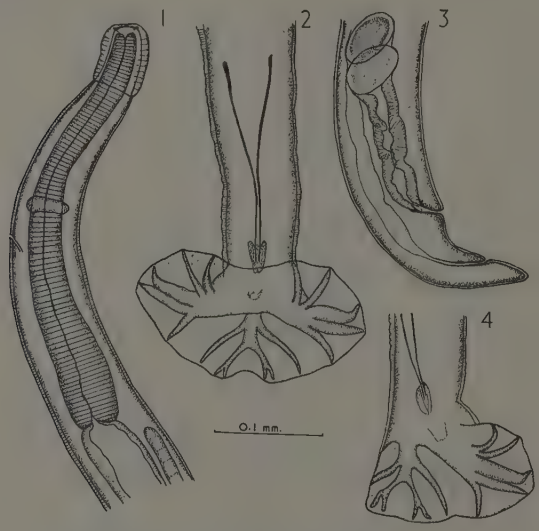
Longistriata kenyae sp.nov.

The worms are small nematodes with conspicuous transverse cuticular striations and with thirteen longitudinal ridges. It appears that between the cuticular layering there are precipitations that make the fixed worms rather opaque and difficult to study. The head cuticle is inflated, 0·06 mm. in length and 0·04 mm. in diameter.

Female: The female measures from 3·0–3·9 mm. in length, with a maximum diameter of 0·1 mm. The undivided muscular oesophagus is 0·38–0·43 mm. in length. The nerve-ring and excretory pore are respectively 0·17–0·20 mm. and 0·24–0·26 mm. from the anterior end of the worm. The tail is 0·05 mm. long. The vulva is near the tail, 0·11–0·13 mm. from the caudal end. There are about 20 eggs in the uterus. The ovoid eggs measure 63–67 by 42–46 microns.

Male: The single male is 2·4 mm. in length and 0·09 mm. in maximum diameter. The oesophagus is 0·35 mm. long. The nerve-ring and excretory pore are respectively 0·16 mm. and 0·23 mm. from the anterior end. The slender, lightly sclerotized spicules

measure 0·18 mm. in length. It is supplemented with a heavily sclerotized gubernaculum 0·03 mm. long. There is a well-developed genital cone.



Longistriata kenyae sp. nov.

Fig. 1.—Anterior end of worm. Fig. 2.—Ventral view of bursa. Fig. 3.—Caudal end of female. Fig. 4.—Dorso-lateral view of bursa.

The bursa, large and well-developed, is supported by rays typical of the genus. The entire bursa has a pitted pattern. The two ventral rays are equal in size and are apart. The antero-lateral and medio-lateral rays are stout and run parallel except for the distal tip, where the antero-lateral tip bends sharply ventrad. The postero-lateral is small, as are the dorsal rays.

Discussion : This species with its short spicules belongs to the subgenus *Brevispiculoides* Ortlepp, 1939. It has some resemblance to *Longistriata* (*B.*) *epsilon* (Travassos, 1937) Skrjabin and Schikhobalova, 1952 ; and to *Longistriata* (*L*) *gracilis* (Baylis, 1928) Dikmans, 1935. It, however, differs from *Longistriata epsilon* in that the two ventral rays are of equal size, the antero-lateral and medio-lateral rays are much larger than the other rays, and it has

spicules of almost double the length. It differs from *L. gracilis* in having fewer longitudinal ridges, spicules of shorter length, lateral rays of the bursa much larger than the dorsal rays, and a medio-lateral ray only secondary in stoutness to the antero-lateral.

Host : *Rattus rattus kijabius*, House rat.

Habitat : Intestine.

Locality : Mwanza, Kenya.

Types : In the Helminthological Collection, London School of Hygiene and Tropical Medicine.

The genus *Longistriata*

Thomas (1953) described three new species of *Longistriata*, two of which, namely *L. codrus* and *L. trus* certainly do not belong to *Longistriata*, and we propose to erect a new genus *Longistrioides* for their reception. *Longistrioides* is easy to differentiate from *Longistriata* which has a symmetrical bursa, and a dorsal ray shorter than the laterals. The dorsal ray has some resemblance to *Impalaia*, but in other respects it is very different.

Members of the genus *Longistriata* are essentially parasites of Rodentia, while those of the genus *Longistrioides* are parasites of Insectivora.

Longistrioides gen. nov.

Diagnosis : Heligmosomidae Cram, 1927. Small worms ; cuticle with transverse striations and longitudinal ridges ; head with cephalic inflation. *Male* : Bursa well-developed and asymmetrical ; ventro-ventral and latero-ventral rays widely separate with difference in size inconspicuous ; antero-lateral and medio-lateral rays parallel in proximal half, but separated in distal half, while the postero-lateral is entirely separate ; dorsal ray large, stout and longer than lateral rays, bifurcating at distal end ; externo-dorsals present. Spicules equal in length, simple and slender. Gubernaculum present. *Female* : Single genitalia. Vulva near anus ; tail blunt.

Parasites of Insectivora.

Genotype : *Longistrioides codrus* (Thomas, 1953) n. comb. In *Sorex* spp., Europe.

Other species : *L. trus* (Thomas, 1953) n. comb. In *Sorex* spp., Europe.

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Journal of Helminthology, Vol. XXXII, Nos. 1/2, 1958, *pp.* 93–98.

A Redescription of *Pulmostrongylus herpestis* (S. Khera, 1956) n. comb. from the Lung of a Mongoose, *Herpestes* sp., from Suva, Fiji

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One male and four female specimens were recovered from the pleural cavity of a mongoose in Fiji by Mr. C. B. Symes, who sent it to Professor J. J. C. Buckley whom I wish to thank for the privilege of examining the material and his interest in the study.

Metastrongylidae Leiper, 1908

Pulmostrongylus Hsu, 1935

Syn. *Herpestostrongylus* Khera, 1956

Pulmostrongylus herpestis (Khera, 1956) n.comb.

The worms are comparatively small and have a thick smooth cuticle devoid of any striations or ridges. There are no lips. The mouth opening is surrounded by two circles of papillae. The inner circle consists of six papillae, while the outer circle has four submedian papillae terminating in a slight cuticular enlargement and two lateral amphids.

Female : These are slender worms measuring 13·4–15·0 mm. in length and 0·13–0·16 mm. in maximum breadth. The body attenuates at both ends, but the tail-end tapers gradually into a long slender tip. The entirely muscular oesophagus is 0·39–0·43 mm. long, fairly uniform in size, and ends in a slight posterior enlargement. The nerve ring is 0·18–0·19 mm. from the anterior end, while the cervical papillae end at the same level, and each project from a slight conical cuticular enlargement. The excretory pore is not clear. The vulva opens into a cuticular bulge, 0·80–0·88 mm. from the caudal end. The anus is 0·40–0·44 mm. from the posterior end, and is constantly half-way between the vulva and the caudal end. The eggs *in utero* were not suitable for satisfactory measurement.

Male : The single male specimen measures 10·4 mm. in length by 0·14 mm. in maximum breadth. The oesophagus is 0·27 mm. long. The nerve ring and cervical papillae are at the same level, 0·16 mm. from the anterior end. The excretory pore is far anterior, 0·05 mm. from the mouth. The spicules are 0·092 mm. in length. They are short, stout, equal and similar. The large gubernaculum, 0·038 mm. in length, is almost triangular in shape. The bursa is supported by thin rays. The ventrals are equal, parallel and split half-way up. The laterals have a common trunk, and consist of a distinct antero-lateral and medio- and postero-laterals which are fused for more than half their length. The externo-dorsal rays originate independently of the dorsal ray. The dorsal ray bifurcates half-way down and each branch indistinctly bidigitate.

Host : *Herpestes* sp. Mongoose

*(Probably either *Herpestes auropunctatus*, the small Indian mongoose, or *H. javanicus*, the Javan mongoose).

Habitat : Pleural cavity

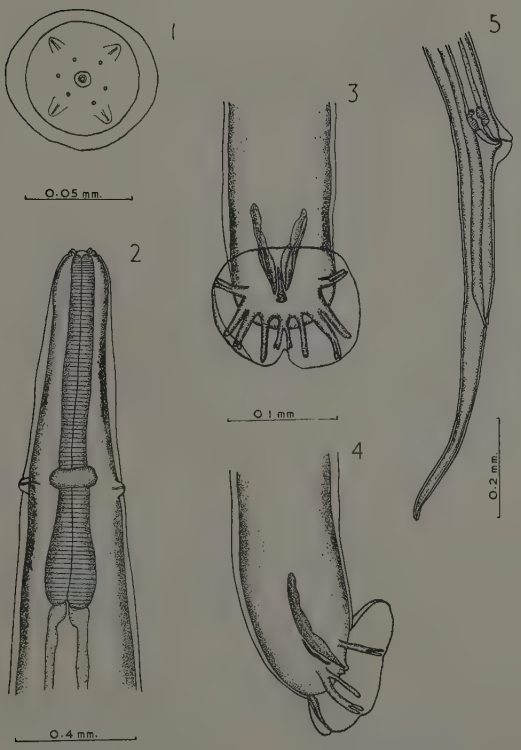
Locality : Suva, Fiji

Discussion

The genus *Pulmostrongylus* H. F. Hsu, 1935 was proposed for *Pulmostrongylus fengi* from a mongoose, *Herpestes urva* from Indo-China. Its habitat appears to be uncertain as the author gives it as, "Bronchus (originally labelled as peritoneum)". Dougherty (1946) in a review of *Aelurostrongylus* and related genera made some unnecessary re-arrangements, and from the study of the present species, we cannot agree with his synonymy, but consider *Pulmostrongylus* to be a valid genus.

Pulmostrongylus herpestis is the only other species in the genus. It appears quite likely that *Pulmostrongylus fengi*, originally labelled as "peritoneum" also comes from the pleural cavity. *P. herpestis* differs from the genotype by its smaller size, much larger gubernaculum and the relative position of the anus which is midway between the vulva and the caudal end of the worm.

* I am indebted to Mr. John E. Hill of the Mammal Section of the British Museum (Natural History) for information regarding *Herpestes* spp



Pulmostrongylus herpestis (S. Khera, 1956)

Fig. 1.—*En face* view of head. Fig. 2.—Ventral view of anterior part of worm. Fig. 3.—Ventral view of bursa. Fig. 4.—Lateral view of bursa. Fig. 5.—Lateral view of female tail.

Key to the species of *Pulmostrongylus*

1. Female with short tail about 0·42 mm. and anus midway between vulva and caudal end of worm. Male with large gubernaculum about 0·38 mm. ... *P. herpestis* (Khera, 1956)

2. Female with long tail about 1·3 mm. and anus close to vulva. Male with small gubernaculum about 0·015 mm. ... ... *P. fengi* H. F. Hsu, 1935

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Addendum

The above species was originally described by me as a new species of *Pulmostrongylus*, but while the paper was still in the press, there appeared a paper :—

Khera, S., 1956.—"Nematode parasites of some Indian Vertebrates." *Indian J. Helminth.*, 6(2), 27–133. [September, 1954].

in which the author described the same species as a new genus and species, *Herpestostrongylus herpestis*. I have consequently withdrawn my species to appear as a redescription of the Indian one, and wish to make some comments on the systematic position of the worm. In his paper, Khera states :—

"The new genus *Herpestostrongylus* is closely allied to *Aelurostrongylus* Cameron, 1927 and *Pulmostrongylus* Hsue, 1935. However, it differs from both the genera in the presence of a minute chitinous vestibule, a bilobed bursa, a chitinous ring on the cloacal aperture and an inverted Y-shaped accessory piece. It further differs from *Aelurostrongylus* in the absence of lip-like

structures and the presence of two circlets of papillae. From *Pulmostrongylus*, it differs further in the absence of telamon."

The genus *Herpestostrongylus* as proposed by Khera is certainly untenable. The "minute chitinous vestibule" he mentions is common to practically all so-called "buccal cavity absent" nematodes. I do not agree that a slight kink in the bursal membrane or a difference in the shape of the gubernaculum should be given generic status. I therefore have no hesitation in proposing that *Herpestostrongylus* S. Khera, 1956 be placed as a synonym of *Pulmostrongylus* H. F. Hsu, 1935, and the species therefore be *Pulmostrongylus herpestis* (S. Khera, 1956) n.comb.

With regard to Khera's paper it will not be inappropriate to make a few comments on some of the other genera which are described. On pages 44–47, Khera describes *Acanthoxynema lucknowensis* n.g., n.sp. as follows: "Only one [soft] female specimen was recovered from the intestine of goat at the slaughter house at Lucknow in April, 1952." From his description and drawings, it is doubtlessly *Skrjabinema*, and probably *Skrjabinema ovis* (Skrjabin, 1915), the common goat parasite. The author says "the worm is soft", etc. which is quite understandable, as his figure 12, a drawing of the anterior region of the "head", shows a badly mutilated anterior region which appears not unlike a *Skrjabinema* minus a head. I am almost certain that his so-called papillae and spines on the head are the rough edges of the broken cuticle. The genus *Acanthoxynema* S. Khera, 1956 is therefore placed as a synonym of *Skrjabinema* Vereshchagin, 1926.

On pages 114–117, Khera describes a new "filarial worm" *Papillosclerus erinaceus* n.g., n.sp. belonging to a new subfamily Osleriinae, placed in the family Dipetalonematidae Wehr, 1935. "Three female worms, two complete and one broken, were recovered from the lungs of the hedge-hog, *Erinaceus* sp." In my experience, *Papillosclerus* Khera, 1956 appears to be the well-known lung worm, *Metathelazia* Skinker, 1931 of the lungworm group Metastrongylidae Leiper, 1908. How the author found grounds for placing it under Dipetalonematidae Wehr, 1935 of the filarioids, is completely uncomprehensible. *Papillosclerus* Khera, 1956 should therefore be placed as a synonym of *Metathelazia* Skinker, 1931 and the subfamily Osleriinae Khera, 1956 supressed.

Summary

A brief redescription is given of *Pulmostrongylus herpestis* (Khera, 1956) recovered from the pleural cavity of a mongoose, *Herpestes sp.* from Suva, Fiji. The genus *Herpestostrongylus* Khera, 1956 is shown to be untenable and placed as a synonym of *Pulmostrongylus* Hsu, 1935. The genus *Acanthoxynema* Khera, 1956 is shown to be a synonym of *Skrjabinema* Vereshchagin, 1926; and the genus *Papillosclerus* Khera, 1956, a synonym of *Metathelazia* Skinker, 1931 and its subfamily Osleriinae Khera, 1956 is supressed.

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Journal of Helminthology, Vol. XXXII, Nos. 1/2, 1958, pp. 99–114.

A Review of the Trematode Genus *Encyclometra* Baylis and Cannon, 1924

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Distomes belonging to this genus were first described by Rudolphi (1819) as *Distoma colubri murorum*. Since then the European species took three further names under *Distoma*, viz., *Distoma allostomum* Diesing, 1850; *D. caudatum* Polonio, 1859 and *D. subflavum* Sonsino, 1892. (Dollfus, 1929). In the same year four independent workers in Europe proposed the erection of a new genus, two of them (Baer, 1924; Baylis and Cannon, 1924) being published on the same day. Since then five new Asian species were added, of which we find only two to be valid species. The addition of these two species has necessitiated the amending of the generic characters as follows :—

Encyclometra Baylis and Cannon, 1924 emend nov.

Syn. *Odhneria* Baer, 1924 *nec* Travassos, 1921

Paraplagiorchis Dollfus, 1924

Orthorchis Mödlinger, 1924

Fairly large *Plagiorchiidae*. The body is flat, translucent with cuticle devoid of spines. The suckers are well developed and approximately of equal size. The caeca are straight, equal or unequal in length. The excretory bladder is Y-shaped and with a voluminous stalk. The testes are either smooth or slightly lobed, and either tandem or diagonally placed. The cirrus sac is well developed and situated on the anterior border of the ventral sucker and contains a coiled seminal vesicle, pars prostatica and cirrus. The common genital pore is to the left of the anterior border of the ventral sucker. The ovary is near the posterior border of the ventral sucker. A Laurer's canal and seminal receptacle is present. The uterus

descends in undulating waves along the right and ascends along the left, dorsal to the testes. The vitelline follicles extend along the lateral fields from the posterior border of the ventral sucker to the caudal end of the worm. The posterior ends of the vitelline ducts are united. Eggs are numerous. Parasites of Reptiles.

Genotype : *Encyclometra colubrimurorum* (Rudolphi, 1819) Dollfus, 1929

Other species :

E. asymmetrica Wallace, 1936

E. japonica Yoshida and Ozaki, 1929
Syns. *E. microrchis* Yamaguti, 1933
E. koreana Park, 1940
E. vitellata N. K. Gupta, 1954

Key to the species of *Encyclometra*

1. Caeca equal ... ... *E. colubrimurorum* (Rud. 1819)
   Caeca unequal 2
2. Caeca subequal ... *E. japonica* Yoshida & Ozaki, 1929
   Caeca very unequal ... ... *E. asymmetrica* Wallace, 1936

Encyclometra colubrimurorum (Rudolphi, 1819) Dollfus, 1929

Synonyms :
Distoma colubri murorum Rudolphi, 1819
D. allostomum Diesing, 1850
D. caudatum Polonio, 1859
D. subflavum Sonsino, 1892
D. sp. No. 1. Timotheev, 1900
Odhneria bolognensis Baer, 1924
Encyclometra natricis Baylis and Cannon, 1924
Paraplagiorchis timotheevi Dollfus, 1924
Encyclometra bolognensis (Baer, 1924) Baylis and Cannon, 1924
Orthorchis natricis Mödlinger, 1924

My collection of this species consists of specimens from grass-snakes, *Natrix natrix* from England.

The worm has a length of 2·9–4·9 mm. and a maximum width of 0·9–1·5 mm. The cuticle is devoid of spines. The subterminal oral sucker is 0·45–0·55 mm. in diameter, and is slightly smaller than the ventral sucker which is 0·59–0·65 mm. There is a short prepharynx and an oesophagus. The ovoid pharynx has a length and breadth

Fig. 1.—*Encyclometra asymmetrica* from *Natrix piscator* from China.
Figs. 2–4.—*E. colubrimurorum* from *Natrix natrix* from England.

varying between 0·25–0·33 mm. and is surrounded by groups of oesophageal glands. The straight caeca end near the caudal end of the worm and are always of equal length. The Y-shaped execretory bladder is a voluriornous tubular chamber before its bifurcation between the anterior testis and ovary where it recives the two lateral excretory tubules

The smooth or lightly lobed testes measure 0·24–0·31 mm. in diameter, are median, tandem in position and ventral to the uterus. The curved cirrus sac is about 0·55–0·64 mm. in length and lies on the anterior border of the ventral sucker. It contains the coiled seminal vesicle leading into the pars prostatica and cirrus. The common genital pore opens between the left caecum and the anterior left border of the ventral sucker at the approximate position of two o'clock.

The spherical or slightly elongated ovary is 0·20–0·24 mm. in diameter and lies on the immediate posterior border of the ventral sucker. The coiled Laurer's canal is dorsal and terminates near the Mehlis' gland. A small globular seminal receptacle and a large mass of Mehlis' gland are present. The follicular vitellaria extend along the lateral fields starting between the ovary and testes down to the caudal end of the worm. The vitelline duct forms a complete circuit with the two anterior ends joining the vitelline reservoir and the posterior ends are united. The uterus descends along the right side of the worm in undulating waves and ascends on the left in like manner. Its path is essentially dorsal to the testes. The eggs measure 75–84 by 38–46 microns.

Host: *Natrix* spp. and *Coluber* spp.

Location: Stomach and lower oesophagus

Distribution: Europe

Life history: Unknown

Discussion. The list of synonyms we have accepted is the list provided by Dollfus (1929) which is now generally accepted and needs no further treatment.

From our study consisting of material from Asia, Europe and Africa, we believe this species to be essentially endemic in Europe and in various species of *Natrix* and *Coluber*.

Encyclometra asymmetrica Wallace, 1936

E. asymmetrica Wallace, 1936 pp. 357–364

E. asymmetrica of Chiang, 1951 pp. 201–215

This plagiorchiid was first described by Wallace (1936) from Canton, China and has not been reported elsewhere. The latter half

of the life history has been studied by Chiang (1951) also from Canton. While in Canton, I have found this parasite to be very common among grass-snakes in that area.

The worm is flat, elongate and translucent, measuring 8·0–10·3 mm. in length and 0·9–1·2 mm. wide. The cuticle is devoid of spines. The oral sucker is subterminal, 0·57–0·59 mm. in diameter, and usually slightly larger than the ventral sucker which is 0·51–0·54 mm. across. There is a short prepharynx and oesophagus. The ovoidal pharynx is about 0·3–0·35 mm. long, and is surrounded by groups of oesophageal glands. The caeca are very unequal, the right one being only two-thirds the length of the left one. The excretory bladder is a large tubular chamber and extends right from the caudal end of the worm up to the ovary before receiving the two lateral branches.

The testes are in tandem, 0·47–0·48 mm. in diameter, being median and ventral to the uterus. The cirrus sac occupies the area immediately anterior to the ventral sucker, or its anterior-third. It has a length of 0·73 mm. and contains a coiled seminal vesicle which leads into the pars prostatica and cirrus. The common genital pore opens close to the left caecum and the anterior lateral border of the ventral sucker, roughly at two o'clock.

The spherical ovary is 0·25–0·28 mm. in diameter and is situated immediately posterior to the ventral sucker and slightly to the right. The convoluted Laurer's canal takes a left and dorsal course. There is a small spherical seminal receptacle and a large globular mass of Mehlis' gland. The follicular vitellaria extend along the lateral fields starting between the ovary and anterior testis right to the posterior end of the worm. The vitelline ducts form an unbroken circuit; they join at the posterior end while anteriorly the other two ends join the vitelline reservoir. The uterus descends along the right side in undulating waves to the caudal end of the worm, and ascends in like manner along the left side. The ovoid eggs measure 94–97 by 49–52 microns.

Hosts :

Natrix piscator (Schneider)	Wallace, 1936 Chiang, 1951 Yeh, present paper
N. stolata (L)	Wallace, 1936

Enhydris chinensis (Gray)	Wallace, 1936
E. plumbea (Boie)	Wallace, 1936
Ptyas korros (Schlegel)	Wallace, 1936
P. mucosus (L)	Wallace, 1936

Experimental hosts :

Takydromus sexlineatus meridionalis, Lizard	Chiang, 1951
Calotes versicolor, Lizard	Chiang, 1951

Second intermediate host :

Macropodus opercularis, Fish	Chiang, 1951

Location in final host : Stomach and lower oesophagus.

Distribution : Canton, China.

Life history : The latter half of the life history has been studied by Chiang (1951). He describes in detail the metacercariae which were embedded either superficially or deeply in the muscle of the paradise fish, *Macropodus opercularis*. When these metacercariae were fed to lizards, (*Takydromus sexlineatus meridionalis* and *Calotes versicolor*) adults were obtained after 18–33 days depending on the daily room temperature.

Discussion. The worms in my collection appear to be very much larger than those of Wallace (1936). Chiang (1951) suspected that Wallace was dealing with a mixture of two species, as both *Encyclometra asymmetrica* and *E. japonica* [*E. koreana*] are common in Canton snakes (Chiang, 1951 ; Yeh, present study), but Wallace made no record of the latter species.

Encyclometra japonica Yoshida and Ozaki, 1929

Synonyms :

E. bolognensis of Bhalerao, 1926, pp. 4–5

E. caudata of Joyeux and Houdemer, 1928, p. 47

E. caudata of Mehra, 1941, pp. 43–50

E. japonica of Yamaguti, 1933, p. 80

**E. microrchis* Yamaguti, 1933, pp. 80–82
E. colubrimurorum of Bhalerao, 1936, p. 195
E. japonica of Yamaguti, 1936, pp. 570–571
**E. koreana* Park, 1940, pp. 113–117
E. koreana of Chiang, 1951, pp. 201–215
**E. vitellata* N. K. Gupta, 1954, pp. 139–141

My material consists of several collections from various hosts from China, India and Africa. The material from Africa from *Naja haje* constitutes a new host record and appears to be the first record of this genus from Africa.

The worm measures 2–6 mm. in length and 0·7–1·6 mm. in width. It reaches its maximum width in the vicinity of the ventral sucker. The cuticle is devoid of spines. The subterminal oral sucker measures 0·36–0·63 mm. in diameter. The ventral sucker is 0·40–0·76 mm. in diameter being slightly larger than the oral sucker. The prepharynx and oesophagus are short. The ovoid pharynx measures 0·17–0·34 mm. in length, and is surrounded by groups of oesophageal glands. The intestinal caeca are straight and reach the caudal end of the worm. They are always unequal, with the left caecum slightly longer than the right one. The large Y-shaped excretory bladder extends to the ventral sucker before receiving the two lateral excretory tubules.

The testes are 0·18–0·50 mm. in diameter and ventral to the uterus. They are either tandem or diagonal in position. If diagonal the anterior testis moves to the left and the posterior testis to the right. The well developed cirrus sac is immediately above the anterior border of the ventral sucker. It contains the coiled seminal vesicle which leads into the pars prostica and cirrus. The common genital pore opens close to the left caecum and the anterior lateral border of the ventral sucker at the "two o'clock" position.

The spherical unlobed ovary is situated at the posterior border of the ventral sucker. A lightly coiled Laurer's canal is present. There is a small seminal receptacle and a large mass of Mehlis' gland. The follicular vitellaria extend along the lateral fields from between the ovary and anterior testis down to the caudal end of the worm. The vitelline ducts form an entire circuit with the posterior ducts united and the anterior ones entering the vitelline

* Described as new species.

reservoir. The uterus is dorsal to the testes, descends along the right side in undulating waves to the caudal end of the worm, and ascends in like manner along the left side. The eggs measure 74–91 by 42–54 microns.

Definitive hosts

	AFRICA
Naja haje	Yeh, present paper, new host record and geographical distribution
	BURMA
Natrix piscator	Bhalerao, 1926
	CHINA
Enhydrus plumbeus	Yamaguti, 1933
Natrix piscator	Chiang, 1951
	Yeh, present paper
	INDIA
Natrix piscator	Mehra, 1931
	Gupta, 1954
Ptyas mucosus	Mehra, 1931
	Bhalerao, 1936
	INDO-CHINA
Ptyas mucosus	Joyeux & Houdemer, 1928
	JAPAN
Elaphe quadrivirgata	Yoshida & Ozaki, 1929
	Yamaguti, 1933
Natrix tigrina	Yamaguti, 1933
	KOREA
Elaphe dione	Park, 1940
Natrix tigrina	Park, 1940
Ancistrodon blomhoffi brevicaudus	Park, 1940

Experimental hosts

	CHINA
Calotes versicolor	Chiang, 1951
Natrix piscator	Chiang, 1951
Takydromus sexlineatus meridionalis	Chiang, 1951

JAPAN

Elaphe climacophora	Yamaguti, 1936
E. quadrivirgata	Yamaguti, 1936

Second intermediate hosts

CHINA

Ooeidozyga lima	Chiang, 1951
Rana limnocharis	Chiang, 1951
R. rugulosa	Chiang, 1951.

JAPAN

Rana nigromaculata	Yamaguti, 1936

Location in final host : Lower oesophagus and stomach

Distribution : Africa, Burma, China, India, Indo-China, Japan and Korea

Life history : Yamaguti (1936) in Japan, fed metacercariae from the muscle of *Rana nigromaculata* to *Elape climacophora* and *E. quadrivirgata* and obtained the adults. Chiang (1951) in South China, fed metacercariae from muscles of *Ooeidozygma lima, Rana rugulosa* and *R. limnocharis* to *Takydromus sexlineatus meridionalis* and *Calotes versicolor* and recovered adults in three weeks.

Discussion : Since 1926, this species has been reported under various names. Bhalerao (1926, 1936), Joyeux and Houdemer (1928) and Mehra (1931) called it under the name of its European relative. Then Yoshida and Ozaki (1929) named it *Encyclometra japonica*. Since then, the parasite has been unfortunate enough to be christened three times.

Encyclometra microrchis Yamaguti, 1933 synonym of *E. japonica* Yoshida and Ozaki, 1929.

On the basis of a single specimen from *Enhydrus plumbeus* from Taiwan, China, Yamaguti (1933) proposed a new species because of the "difference in the size of the testes and the extent of the uterus. . . . The host is also entirely different." It is my experience from my collection of *Encyclometra* specimens that minor differences in the size, shape and relative position of the testes are of no importance. What is more, from Yamaguti's drawings, it appears that he was

dealing with a single juvenile worm. The size of the testes as quoted by him reaches the lower range of that given by Yoshida and Ozaki (1929). The extent of the uterus appears to us unimportant when dealing with juvenile forms. As *Encyclometra japonica* grows to the adult stage in both snakes and lizards (Chiang, 1951) there cannot be strict host specificity at all. Park (1940) rightly considered *E. microrchis* to be a synonym of *E. japonica*, and we are in complete agreement with this synonymy.

Encyclometra koreana Park, 1940 synonym of *E. japonica* Yoshida and Ozaki, 1929.

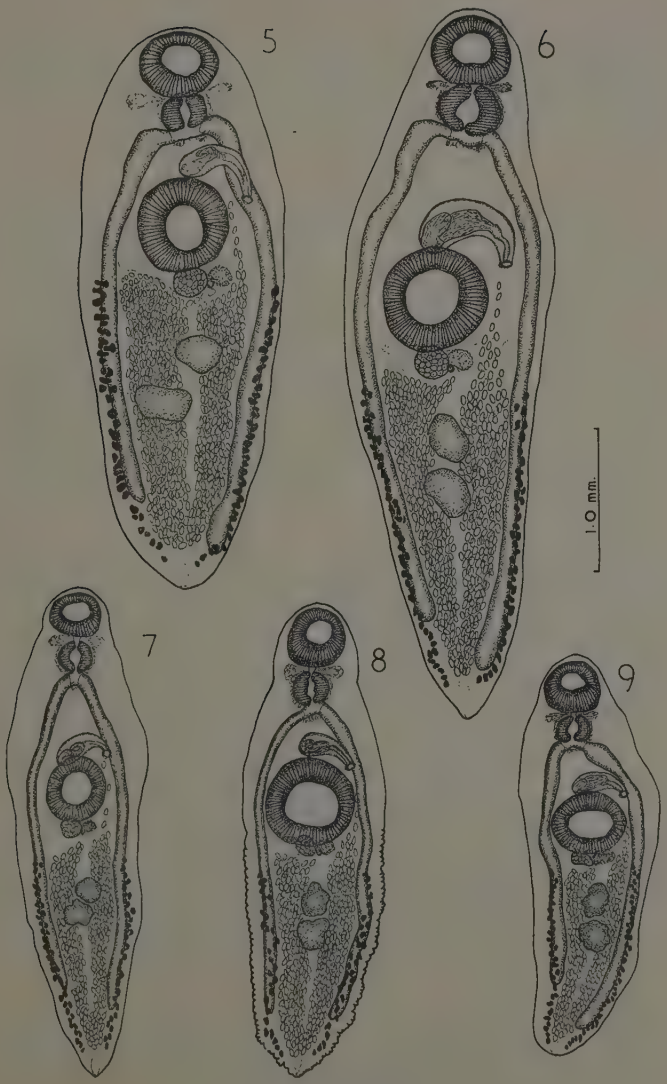
Park (1940) having rightly placed *E. microrchis* as a synonym of *E. japonica*, proposes a new species *E. koreana* which is obviously one and the same species. He states that "the seminal vesicle in *E. koreana* is curled or sinuous, whereas it is simple sac-shaped in *E. japonica*." To quote from Yoshida and Ozaki (1929, p. 240) the author says :—

> "The cirrus pouch is conical, with a slight bend, and extends back from the genital pore obliquely on the dorsum of the acetabulum but does not reach the posterior border of the latter. The pouch has a muscular wall and encloses a large vesicula seminalis, a distinct tubular pars prostatica, a convoluted ductus ejaculatorius and a cirrus. The prostate gland cells are well developed lying around the pars prostatica, within the cirrus pouch."

That is the only statement we could find concerning the seminal vesicle and cannot verify Park's statement of *E. japonica* being "simple sac-shaped and straight". Yoshida and Ozaki (1929, p. 243, Plate I, Fig. 1) on a drawing of a whole mount of *E. japonica* clearly shows the coiling of the seminal vesicle and it is not unlike the drawing by Park. After a close study of the original literature and our collection of *Encyclometra* specimens we have no hesitation in placing *E. koreana* Park, 1940 as a synonym of *E. japonica*.

E. vitellata N. K. Gupta, 1954 synonym of *E. japonica* Yoshida and Ozaki, 1929.

Gupta (1954) considers his specimens to belong to an undescribed species owing to the fact that the vitelline ducts unite at the posterior end of the worm. Three years earlier, Chiang (1951)



Encyclometra japonica

Fig. 5.—From *Natrix piscator* from South China. Fig. 6.—From *Natrix piscator* from India. Figs. 7–9.—From *Naja haje* from Africa. Fig. 8 is a contracted specimen showing the effect of contraction on the caeca.

has shown that the vitelline ducts in *E. japonica* unites at the posterior end. In our present study, we find that this is true for all species of *Encyclometra*, and *E. vitellata* N. K. Gupta, 1954 should therefore be placed in synonymy with *E. japonica*.

Discussion

In regard to the caeca in *Encyclometra columbrimurorum* [*Odhneria bolognensis*], Baer (1924, p. 23) states that :

> "The two coeca extend into the posterior extremity of the body. It is hard to estimate their exact length for in the same specimen, when alive, the length of the coeca varies, attaining sometimes half the original length, without showing any signs of contraction, at one time one coecum was even longer than the other. It seems clear that this character cannot be regarded either as generic or specific, and should not be considered of systematic importance."

Wallace (1936, p. 361), however, seems to believe that the length of the caeca may be of some specific importance. In his discussion on *E. asymmetrica* he stated that :—

> "The author wishes to direct particular attention to the chief distinguishing feature of this new species, the asymmetry of the intestinal caeca, the left caecum always being longer than the right. On the first consideration it may seem that a difference in these organs is not sufficient basis for distinguishing a new species." He then quotes the previous paragraph of Baer's and continue : "Despite this statement the author believes that, whatever may be the case in *E. caudata*, in *E. asymmetrica* the the difference in length of the caeca cannot be considered to be due to fortuitous variation but is an integral feature of the structure of the worm. The caeca were examined in 37 whole mounts and in 6 sets of serial sections as well as in a large number of living specimens, and in every case the left caecum exceeded the right length."

Park (1940, p. 114) states that in *E. japonica* [*E. koreana*] the intestinal caeca are "smooth or wavy, symmetrical or asymmetrical." In his discussion (p. 116) he states that :—

> "In regard to the structure of the caeca, Wallace (1936) has

confirmed on the grounds of forty three specimens of *Encyclometra asymmetrica* studied that the asymmetrical intestinal caeca is a specific character to separate *E. asymmetrica* from *E. caudata*. However, as the table I shows, it is not a specific, but one of individual variation in *E.* koreana."

In this Table I, Park lists three specimens from *Elaphe dione*, two of which have asymmetrical caeca and one with symmetrical caeca. Of three specimens from *Natrix tigrina*, two are again asymmetrical and one with symmetrical caeca. And further two specimens from *Ancistrodon blomhoffi brevicaudus* one has equal and the other equal caeca.

Chiang (1951, p. 211) in a redescription of *E. japonica* [*E. koreana*] from Canton states :—

"Intestinal caeca straight, reaching the posterior end of the body, the left one often slightly longer than the right."

Our observation on the caeca of living trematodes in both this genus and other genera are not in agreement with Baer concerning movements of the caeca. In a comparative study of my available material, we agree with Wallace (1936) that the caeca are important not only in differentiating *E. asymmetrica* from the other species, but also from all three of the valid species. We have found the caeca always to be straight and of constant length in a well fixed specimen, or a living specimen under slight pressure of a cover glass with the correct amount of fluid. In *E. asymmetrica* the caeca are very unequal and no matter what happens to the specimen, they remain unequal. In *E. colubrimurorum* and *E. japonica* it is not so. In *E. colubrimurorum* the caeca are quite equal, and will not become otherwise unless distorted. In *E. japonica* the left caecum is only slightly longer than the right, and they may look symmetrical when the specimen is contracted (Fig. 8). Fortunately the contracted state is easy to observe as in *Encyclometra* the caeca are straight and when the specimen is contracted, the caeca become wavy.

With regard to the uterus, Baer (1924, p. 24) in his generic diagnoses states :

"Uterus passes backwards and forwards behind testes and ventral sucker."

Baylis and Cannon (1924b, p. 559) says of the above :—

> "We would point out that in the generic diagnoses of *Odhneria*, Baer, scarcely sufficient stress has been laid upon the feature that seems to us the most remarkable—namely, the fact that neither the ascending nor the descending limb of the uterus passes between the testes. The typical arrangement of the uterus, with both limbs passing between the testes, is included by M. Baer in his amended diagnosis of the family Lepodermatidae, but the statement in both generic and family diagnoses that the uterus of *Odhneria* passes 'behind' the testes seems to us somewhat ambiguous. Presumably, as the figure indicates, the word 'behind' means 'dorsally to', but in the main the sinuous ascending and descending limbs lie, as we have stated, laterally to the testes."

This criticism of Baer by Baylis and Cannon seems to us to be unreasonable. All my material has shown that Baer is correct is saying that the uterus is dorsal to the testes, which is even more evident in *E. japonica* and *E. asymmetrica*. If Baylis and Cannon had studied cross-sections of *E. colubrimurorum*, they would have been of the same opinion as Baer.

With regard to the vitelline ducts, Chiang (1951) has shown that they are united at their posterior ends in *E. japonica* [*E. koreana*]. This, we have found to be true for the other species in the genus as well, and thus this character has been incoporated in the amended generic diagnosis.

As for the position of the various organs, such as the cirrus sac, ovary and testes, it appears that some of the authors lay too much stress on their exact position. We have purposely shown in Fig. 3 a distorted specimen in which the cirrus sac is moved 90° and still looks perfectly normal, or as in Fig. 2 with the ovary displaced to the extreme right and entirely away from its normal median position. The testes are still more variable, as they may be smooth or lightly lobed. They may be close to each other as in Fig. 3 or far apart as in Fig. 4, or tandem in position as in Fig. 6 or diagonally placed as in Fig. 5. It is rather unfortunate that many authors seem to fix their specimens at the very first opportunity without trying to observe them while living ; in the live state it can easily be demonstrated that various organs are displaceable to some extent by slight pressure of a needle on the cover glass. In this way their maximum movement in all directions can be seen.

SUMMARY

In a review of the genus *Encyclometra*, only three species are considered to be valid : the genotype *Encyclometra colubrimurorum* (Rudolphi, 1819) Dollfus, 1929 ; *E. japonica* Yoshida and Ozaki, 1929 with synonyms *E. microrchis* Yamaguti, 1933, *E. koreana* Park, 1940 and *E. vitellata* N. K. Gupta, 1954 ; and *E. asymmetrica* Wallace, 1936. The intestinal caeca are shown to be a constant, useful and reliable character to differentiate the various species in the genus. In the light of some new information, the genus is slightly amended.

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On an Infection of a Human Eye with *Philophthalmus* sp. in Ceylon

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On August 9th, 1956 one of us (D.P.B.) removed a worm from the eye of a patient. It proved to be a small trematode belonging to the genus *Philophthalmus*. This is the first occasion on which this genus has been found in man or any other host in Ceylon, and is also the first record of a trematode from man in Ceylon.

The patient, an Indian Moor aged 52 years, complained of irritation in his right eye of 3 weeks duration. He had no other symptoms. He is a resident of Ceylon who makes regular trips to South India. On the last occasion he stayed there from February, 1956 to the end of July, 1956. He gives a history of having bathed almost daily in a small stream frequented by ducks and crows, in Tinnevely District, in South India. The irritation of his eye commenced about 4 days before he returned to Ceylon.

On examination a small patch of redness was noticed 4 mm. above the limbus, at 12 o'clock. There was a slight swelling, and under it slow rhythmical movements were observed by Slit-lamp. The conjunctiva was cocainized and broken over the site with a pledget of cotton wool whereupon part of a worm came out and withdrew again. This movement repeated itself several times till the conjunctiva was pressed and the worm emerged. It was alive and motile and was kept in saline till the following morning, when it was sent to Professor V. Sivalingam of the Department of Parasitology, Faculty of Medicine, University of Ceylon.

The patient's symptoms disappeared as soon as the worm was removed, and when examined 5 days after, there were no signs of redness.

Description of the fresh specimen

It is a small trematode moving by slow contraction and relaxation of its body which is spindle-shaped. The ventral sucker is quite large and projects prominently on the ventral surface. The oral sucker is also prominent. Examined under slight pressure of a cover slip, the worm shows almost all details of its structure as is

seen in Plate I. It measures 3·01 mm. in length by 0·96 mm. in maximum breadth. The mouth is terminal and not surrounded by spines. The cuticle is smooth. The cirrus is large and prominent and placed on the left side of the ventral sucker. The cirrus pouch projects well behind the ventral sucker. The oral sucker, ventral sucker and pharynx are seen as prominent muscular structures. There is no oesophagus or prepharynx. The uterus shows a few coils and contains relatively few eggs. The eggs in the anterior coils are larger and contain miracidia with eyespots. The unbranched gut caeca extend to the posterior end. The excretory canals can be seen on either side overlying the intestinal caeca (see Plate I). They drain into an excretory bladder which opens at the posterior entremity of the worm. The ovary is seen hidden behind the coils of the uterus. The pair of testes are in tandem position behind the ovary. The vitellaria could not be discerned.

Description of the stained specimen

The worm was carefully fixed while under the cover slip, and stained in acetic acid alum carmine. It underwent considerable shrinkage, and the measurements and description that follow are from this shrunken specimen. (Fig. 1).

The worm measures 1·56 mm. in length by 0·64 mm. in maximum breadth. The oral sucker is 0·36 mm. by 0·18 mm. There is no prepharynx or oesophagus. The pharynx is 0·22 mm. long by 0·18 mm. wide. The intestinal caeca extend almost to the posterior end of the worm, where their blind ends lie close to each other and to the excretory bladder. The ventral sucker is large and measures 0·36 mm. by 0·32 mm. It lies 0·45 mm. from the anterior end of the worm and 0·072 mm. from the bifurcation of the gut.

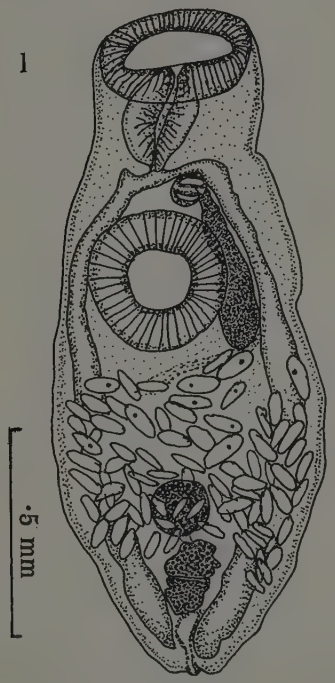
The gonads lie in the posterior third of the worm. The ovary is anterior to the two testes, is spherical and measures 0·14 mm. in diameter. The two testes which are slightly lobed, lie in tandem position. The anterior one is more or less round and measures 0·11 mm. by 0·09 mm., while the posterior is triangular in outline and measures 0·09 mm. by 0·07 mm.

The cirrus pouch which is 0·38 mm. long and 0·09 mm. at its widest point, is situated on the left side of the ventral sucker. The common genital atrium opens just behind the bifurcation of the gut, slightly to the left of the mid-line.

The uterine coils extend from the level of the anterior testis to behind the posterior border of the ventral sucker. The eggs are operculated and in the anterior coils contain a developed miracidium

with eyespots at the broader anterior end. These eggs measure 0·068–0·079 mm. by 0·029–0·036 mm. (average 0·073 by 0·033 mm.).

The vitellaria are not distinguishable, and as only a single specimen of the worm is available no attempt has been made to restain it.



Philophthalmus sp.

Fig. 1. Drawing of ventral view of worm, after staining.

Although several trematodes belonging to the genus *Philophthalmus* Looss, 1899 have been reported from birds, there is only one record of this genus from man which was reported by Markovic (1939) in Belgrade. He was of the opinion that the parasite was *P. lacrymosus* Braun, which had previously been found in a gull in Brazil and which later he and Garzicic (1939) found in gulls in Belgrade. They believed that they were dealing with a direct infection of the patient's conjunctiva while he was bathing in the Sava river. As the developmental cycle of any member of this

genus is unknown, they did not come to a definite conclusion regarding the mode of entry of the parasite.

In the present case, we are handicapped by the fact the vitellaria have not shown up in the stained preparation, so a definite diagnosis of the species cannot be made. Furthermore, no previous records of this genus are available in Ceylon, and only two species have been reported from India (Jaiswal and Singh, 1954). The fact that human infections with this genus are so rare, suggests that the two cases so far recorded are accidental infections of man. This is borne out further by the observations that in birds, which are the normal hosts of this genus, the worms do not produce any pathological effects ; whereas in Markovic's case there was follicular conjunctivitis and in the present case there was redness and irritation ; and in both cases the lesions disappeared after the worms were removed.

As the patient was in South India for about 6 months, there is little doubt that the infection took place there, but the mode of infection can only be surmised. An already adult fluke may have fallen off the eye of a bird and invaded the eye of the patient while he was bathing or, more probably, the infection took place through the cercaria stage either directly or via the blood stream. It is our opinion that the cercaria has directly entered the conjunctiva and developed to maturity there, but that a decision on the exact mode of infection must await the discovery of the life-cycle of even one member of the family Philophthalmidae.

Summary

1. A human case of *Philophthalmus* infection in the eye is reported from Ceylon. Reasons are given for not attempting a specific diagnosis.

2. This is the second record of this genus from man, and is also the first trematode to be observed from man in Ceylon.

We are grateful to Professor V. Sivalingam for facilities to identify and report on the parasite, and to Professor J. J. C. Buckley for his suggestions. The photomicrograph was kindly prepared by Mr. R. Surendranatham of the Medical Research institute, Colombo.

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Plate I. *Philophthalmus* sp. Photomicrograph of fresh worm under coverslip (×37)

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Protein Metabolism in Trematode Parasites

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Following the classical experiments of Weinland (1901 and 1904) on the metabolism of helminth parasites, considerable work has been done on this subject in recent years. The accumulated literature, an indirect measure of the interest shown by world workers in this branch of science, has been reviewed by McCoy (1935), von Brand (1938), von Brand and Jahn (1942), Smyth (1947), Hobson (1948), Bueding (1949) and von Brand (1952).

While the metabolic behaviour of cestodes and nematodes has received considerable attention, little work appears to have been done on the metabolism of trematodes. In trematodes also, most of the investigations deal chiefly with the metabolic behaviour of *Fasciola hepatica*, probably on account of its larger size.

In *F. hepatica*, Weinland and von Brand (1926) found 58% protein of dry substance. Reports of Flury and Leeb (1926) and van Grembergen and Pennoit De Cooman (1944) on the same species showed the presence of ammonia and amino acids and the absence of urea and uric acid in the end-products of protein metabolism.

The present paper deals with the studies conducted on the protein metabolism of three trematodes namely, *Paramphistomum explanatum*, *Gastrothylax crumenifer*, and *Fasciola gigantica*.

Material and Methods

P. explanatum, and *F. gigantica* were collected from the bile ducts and *G. crumenifer* from the reticulum of buffalos slaughtered at the local abattoir.

The parasites were washed in saline till free of debris, and then washed several times in sterile saline. They were rolled on a piece of dry filter paper to remove any remaining surface moisture. The wet weight of the worms was obtained and their dry weight determined by keeping worms of known weight in a drying oven, at 100°C., and subsequently weighing the samples, when completely dry.

The nitrogen was estimated by the Kjeldal method.

For *in vitro* experiments for analysing the end-products of protein metabolism, the method suggested by Rogers (1952) was used. This consisted in culturing the parasites under aerobic conditions at 37°C. in a non-nutrient medium containing streptomycin and penicillin buffered at *p*H 6·8. The weighed samples of different parasites were taken and kept in Petri-dishes in 25 ml. of the original isotonic medium. At intervals of two hours, measured volumes of the solution were removed for different estimations.

Ammonia was estimated by the direct Nesslerization method of Folin and Denis (1916).

Uric acid was estimated by the colorimetric method of Benedict and Franke (1922) using a photoelectric absorptiometer.

Urea was estimated by first converting it into ammonia by the action of urease and the quantity of ammonia formed was estimated colorimetrically after nesslerization. The amount of ammonia originally present was estimated in a second sample which has not been treated with urease, and the concentration of urea determined by subtraction.

Creatinine was estimated by the colorimetric method of Folin (1914) using a photoelectric absorptiometer.

Results

(a) *Total body protein content.

The results of twenty analyses carried out with several lots of *P. explanatum*, *G. crumenifer* and *F. gigantica* showed that the protein content in terms of dry weight of tissue ranged from 50·0% to 54·7% with the mean at 52·96% ± 0·23 in case of *P. explanatum*,

* The figures for protein given above have been obtained by multiplying the Nitrogen content by 6·25.

from 43·5% to 51·5% with the mean at 48·8% ± 0·56 in *G. crumenifer* and from 63·8% to 68·3% with an average of 66·5% ± 0·26 in *F. gigantica*.

(b) End-products of Protein Metabolism.

The results of fifteen analyses carried out with several lots of the three experimental parasites showed that in all of them a gradual increase in the amount of excreted ammonia and uric acid occurred at the progressive two-hourly intervals. It was lowest at the end of the first two hours and highest at the end of twelve hours. Statistical analysis revealed that the difference in the amount of excreted ammonia and uric acid at two-hourly intervals was highly significant. Highly significant variation was also observed between sample and sample.

The quantity of nitrogen in the form of excreted ammonia and uric acid was then compared with the total body nitrogen.

In *P. explanatum* the total body nitrogen present was 8·47% of d.w.t. (dry weight tissue) and it was found that the amount of excreted nitrogen in the form of ammonia increased from 2·17% of the total body nitrogen (t.b.n.) after the first two hours to 3·95% of the t.b.n. after twelve hours, while the amount of excreted nitrogen in the form of uric acid increased from 0·015% of the t.b.n. after the first two hours to 0·033% of the t.b.n. after twelve hours.

In *G. crumenifer* the total body nitrogen present was 7·8% of d.w.t. and it was found that the amount of excreted nitrogen in the form of ammonia increased from 1·18% of the t.b.n. after the first two hours to 2·9% of the t.b.n. after the lapse of twelve hours while the amount of excreted nitrogen in the form of uric acid increased from 0·015% of the t.b.n. after the first two hours to 0·033% of the t.b.n. after twelve hours.

In *F. gigantica* the total body nitrogen present was 10·64% of d.w.t. and the amount of excreted nitrogen in the form of ammonia increased from 1·41% of the t.b.n. after the first two hours to 2·51% of the t.b.n. after twelve hours, while the amount of excreted nitrogen in the form of uric acid increased from 0·038% of the t.b.n. after the first two hours to 0·10% of the t.b.n. after twelve hours.

Urea and creatinine were not detected in any of the parasites studied.

Discussion

The total protein found in these studies namely 52·96% in *P. explanatum*, 66·5% in *F. gigantica* and 48·8% in *G. crumenifer*, compare with the figures obtained by other workers in other parasites. Thus Weinland and von Brand (1926) found 58% in *Fasciola hepatica*, Smorodincev and Bebesin (1936) 60% in *Diphyllobothrium latum*, Flury (1912) 54% in *Ascaris lumbricoides* and von Brand (1939) 70% in *Macracanthorhynchus hirudinaceus*. In most of these cases the protein content was found to be more than the sum of glycogen and fat.

According to the present investigations the end-products of protein metabolism for each one of these three parasites were found to be the same. The nitrogen was mainly excreted in the form of ammonia and uric acid. In *P. explanatum* about 4% of t.b.n. in the form of ammonia and 0·077% of uric acid is excreted in a period of twelve hour starvation under aerobic conditions. In identical conditions *F. gigantica* excreted 2·51% of the t.b.n. in the form of ammonia and 0·10% of uric acid, whereas in *G. crumenifer* the ammonia excreted was only 2·9% and uric acid 0·0332% of the t.b.n.

The results of the present investigations are in accord with the observation that small sized animals generally have a comparatively higher rate of metabolic activity. *F. gigantica* is the largest of the three parasites and it is seen from the results that the ammonia excreted by it is only 2·51% of the t.b.n., whereas *P. explanatum* has the smallest size but it has excreted the highest amount of ammonia viz. 4% of its t.b.n. in the same period and under identical conditions.

The nature of the end-products of nitrogen metabolism is of considerable biological significance (Needham 1931, 1942). As pointed out by Rogers (1952) a large part of the excreted nitrogen in all animals has a common origin but it may be excreted as ammonia, urea or uric acid. Ammonotelic and ureotelic organisms live in environments where there is no acute water shortage while uricotelic organisms usually under such conditions where they have to economize water. Most of the parasites are ammonotelic and in this respect they resemble free-living aquatic organisms (Salisbury and Anderson, 1939). The only parasites apparently producing urea and uric acid together with ammonia in any quantity are the larval tapeworms.

In the three parasites examined here it has been shown that ammonia and uric acid were excreted but no urea. No explanation of this is available at present.

Summary

Paramphistomum explanatum, *Gastrothylax crumenifer*, and *Fasciola gigantica* were maintained for periods of twelve hours in a non-nutrient medium containing streptomycin and penicillin to prevent bacterial growth. They were kept under aerobic conditions at a suitable temperature of 37°C. The protein content in *P. explanatum* ranged from 50·0% to 54·7% with an average of 52·96% ± 0·23 of the dry weight of the tissue. In *G. crumenifer* it ranged from 43·5% to 51·5% with an average of 48·8% ± 0·56 of d.w.t. In *F. gigantica* it ranged from 63·8% to 68·3% with an average of 66·5% ± 0·26 of d.w.t. The nitrogen content of the *P. explanatum* excreted as ammonia after a starvation period of twelve hours was 3·95% and as uric acid it was 0·077%. In *G. crumenifer* the ammonia was 2·91% and uric acid 0·033%. In *F. gigantica* ammonia was 2·51% and uric acid 0·1%.

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The Conduct of Hatching Tests on Cysts of the Potato-root Eelworm *Heterodera rostochiensis* (Woll.)

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Triffitt (1930) showed that larvae were stimulated to hatch from cysts of *H. rostochiensis* by diffusates produced by the roots of growing potato and tomato plants. Although her findings have been confirmed by later workers, no detailed techniques for the conduct of hatching tests have been published. To fill this gap, the authors describe methods for the assay of the samples produced at the Chemical Laboratory, Cambridge in an investigation into the chemistry of the active fraction in potato root diffusate. The present paper deals with general principles and although the approximate magnitude of attendant errors is given, supporting data are not included since statistical considerations and methods of calculation will be discussed in a later paper. The techniques described are concerned only with assays of the hatching factor. To apply them to cysts that have been exposed to nematicides without further investigation would be unjustified.

Collection of Material

Two factors may cause errors in hatching tests : (a) cyst variability which can be reduced by using replicated batches of 100 or more cysts drawn from a single bulk stock of known characteristics ; (b) fluctuations in diffusate activity which can be reduced by using as a control, samples of diffusate drawn from a common stock which has been previously assayed.

Cyst Collection

Cysts are recovered from heavily infested soil collected in September or October. After drying, the soil is washed through a large Fenwick apparatus (Fenwick, 1940); the "float" is collected on a 50 mesh sieve. About one ton of soil is usually dealt with at a time.

The "float" is subsequently shaken with water in a 1,000 ml. measuring cylinder, any silt which is present sinks, and the cyst-containing material can be poured off on to a fine sieve or bolting silk and dried at a temperature of about 24°C. When dry the float is sieved successively through 24, 30, 40 and 50 mesh sieves; the fractions retained by the first and passing through the last are discarded. The remaining fractions are processed separately for the purification of the cysts by hand or mechanical rolling (Goodey 1957, Cooper, 1955). Three rollings if done with care result in the recovery of about 75% of the cysts; the 25% loss is not serious since most of the cysts lost are damaged or misshapen and contain very few eggs. Further purification can be effected by shaking the rolled cysts in a tube of water and exposing the tube to a slight vacuum when many of the foreign particles disintegrate and sink. It is generally found at the end of these operations that foreign particles comprise only about 20–25% of the total cysts recovered. Usually cysts collected in the autumn are stored until the following April before use, because although "winter dormancy" (Fenwick and Reid, 1953) is not usually encountered, it sometimes occurs in the first winter after collection.

Root Diffusate Collection

Active potato root diffusate suitable for use as a standard is collected from potato plants growing in 6 in. pots containing a 3 : 1 mixture of unsterilized loam and sand. The plants are leached three times weekly, about 50 ml. being taken from each pot every time. All samples collected are tested for activity and active samples are pooled into a 10 gallon carboy which is stored in a cold room at 3–5°C where it may be kept up to two years with little loss in activity. Samples are withdrawn by means of a syphon; the first 50–100 ml. are discarded to get rid of the fluid in the syphon tube, and the stock in the carboy is then mixed by blowing in air through the syphon; the sample for experiment is then withdrawn.

Working Techniques

Setting up Randomised Replicate Batches of Cysts

Two methods are available for this process—hand picking and weighing. Whichever method is used, thorough mixing of the mass is essential. A convenient method is to place the stock of cysts in a slowly rotating tube, e.g. a perspex tube 6 in. $\times 1\frac{1}{2}$ in. fastened

to the seconds spindle of an electric clock motor and inclined at an angle of about 30° to the horizontal. If hand picking is used, cysts can be withdrawn by means of a spatula and spread on a cyst counting tray (Fenwick, 1940) and batches of 100 picked up using a suction aspirator (Hesling, 1952). When weighing, it is convenient to have available a variety of differently sized spoons so that batches of cysts of constant and predetermined weights can be selected. The spooned batches of cysts are weighed using a capillary microbalance (Fenwick and Reid, 1951). Cyst batches from three adjacent readings on the microbalance scale are retained for experiment and those beyond these limits are discarded. Thus, all batches of cysts weighing say, 10, 11 and 12 divisions on the scale, corresponding to 5·6, 6·2 and 6·7 mgm., would be used for experiment. The weights of batches chosen are such that they contain 180–200 cysts and can be weighed out at a rate of more than 100 per hour. Counted batches can be set up at the rate of 60 per hour. The batches of cysts are transferred to and stored in solid watchglasses which also serve as containers in which to do hatching tests. Where large numbers of batches are handled, the dishes may be stacked in fives, in drawers with a sliding front and a loose bottom shelf on which 180 stacked watchglasses can be stood. The batches of cysts, whether weighed or counted, must be randomised before use.

Presoaking, Setting up, Subculturing

Hatching tests are carried out on cysts which have been soaked in water for 7–12 days at 25°C. Presoaking is started when randomising, and can be done by running in about 1–1·5 ml. of water from an overhead aspirator when the dishes are individually set out on the randomising board. Solid watchglasses as purchased are usually moulded, and the top and bottom surfaces tend to be uneven. This can be overcome by grinding on a sheet of glass using a paste of No. 100 grade carborundum grit in dilute glycerine after which no difficulty should be experienced from drying out provided a drop of water is placed on the upper surface of each watchglass and the top watchglass is covered with a glass lid.

The "setting up" and "subculturing" of hatching experiments are similar in that they involve the removal of fluid from the watchglasses and its replacement by fresh fluid. When setting up, the fluid removed is discarded but when "subculturing" the liberated larvae must be recovered. The fluid and larvae can be removed from around the cysts by means of a coarse pipette, provided the end is cut off squarely and the pipette is held vertically on the bottom

of the dish. This operation should be carried out on a white surface so that if any cysts are drawn up into the pipette they can be seen. Test solutions are conveniently stored in medicine bottles which are kept in a refrigerator at 3–4°C.

When "setting up," the first twenty watchglasses are set out in a row on the white surface with the bottles containing the appropriate test solution immediately behind each set of replicates. The water is removed from each watchglass in the first set of replicates and discarded. About 1 ml. of test solution is then added to each, then removed and discarded and a further 1–1·5 ml. is added. The next set of replicates is dealt with similarly. It is most important that the pipette be thoroughly washed when passing from one treatment to another.

The procedure for "subculturing" is very similar except that the fluid and larvae removed from the watchglasses and the washings are stored in 3 in. × 1 in. tubes for counting. The bench arrangement for this is shown in Fig. 1. The watchglasses are put out in a row in groups of replicates : immediately behind each group is a wooden block containing 3 in. × 1 in. tubes each numbered to correspond to its own watchglass and behind each block is the bottle of hatching solution. Removal of the fluid from the watchglass followed by a single washing results in the removal of about 95% of the liberated larvae.

The 3 in. × 1 in. tubes containing the larvae are transferred to large storage racks until counting is started. If a few days are likely to elapse before counting, it is advisable to add a little formalin to each tube to prevent dead larvae from putrefying.

With practice it is possible to set up about 100 hatching units per hour or to "subculture" about 80 dishes.

Counting of Eggs and Larvae

The system for counting is shown in Plate I, Fig. 2. The numbered 3 in. × 1 in. tubes containing the larvae are mounted in wooden blocks with rubber pressure tubing built into their backs to hold the tubes firmly in the holes (Fig. 3). It is thus possible to pour the contents of five tubes simultaneously into calibrated boiling tubes held in racks immediately behind the blocks. After pouring, the tubes are washed once with a few ml. of water from an overhead aspirator and the washings transferred to the boiling tubes which

are then made up to a known volume. The suspension is mixed by blowing into the tubes through a pipette after which a sample is withdrawn and transferred to the counting slide (Fenwick, 1951) immediately in front of the blocks.

Provided the dilutions in the calibrated tubes are adjusted so that 1 ml. counts do not exceed 200–300, about 30 counts can be prepared in 20 minutes and counted in 30 minutes so that at least 200 counts can be dealt with in a day.

Estimation of Egg and Larval Content of Cysts

This is best accomplished by the rolling method of Reid (1955) carried out on batches of cysts which have been soaked for at least two days ; the liberated eggs and larvae are counted by the dilution technique just described.

Preliminary Assays

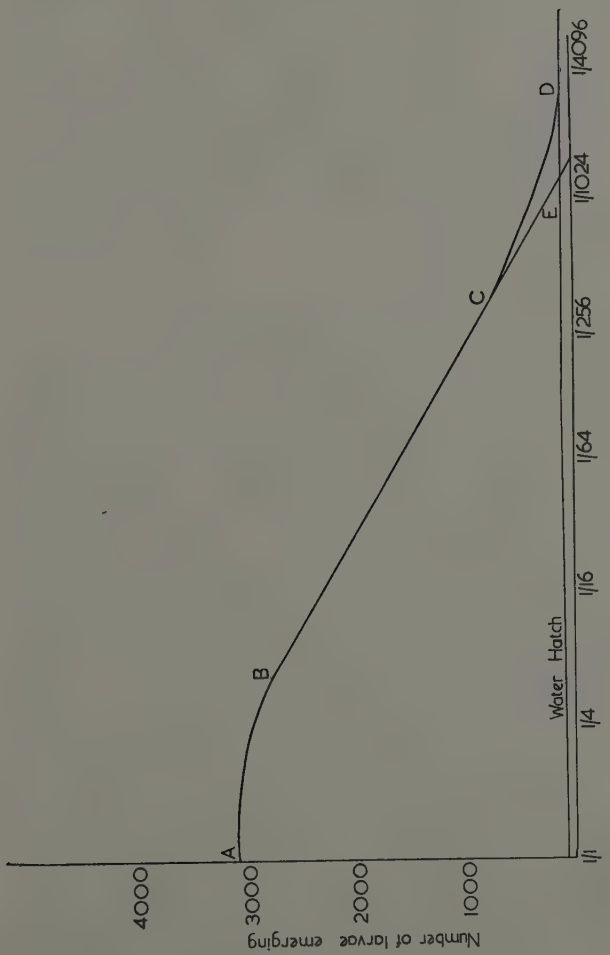
Before embarking on a series of hatching tests, the characteristics of the cysts to be used should be investigated and the presence of any contaminating organisms such as fungi sought. All experimental results must be related to controls and in this case two controls are recognisable. The first, emergence in water in the absence of a stimulatory substance—the spontaneous hatch—is not usually very marked in the case of *H. rostochiensis* but must be estimated ; the second, is the number of larvae which are capable of hatching and the relationship of this to total cyst contents. The two levels thus set the extreme limits between which hatches can be interpreted.

To investigate variability in total cyst contents per batch, 150 batches of about 200 cysts are weighed out, 50 of each of three adjacent weights; a further 150 batches of 100 cysts are hand picked. The number of cysts and particles of debris in the weighed batches are determined and together with the counted batches they are then soaked and dissected and their total contents estimated. Over a large number of such assays on a variety of cyst stocks variability of cyst number rarely exceeds 10–12% within any given weight and rises to 13–14% when three adjacent weights are pooled. The variability of total egg content per hand picked batch is approximately 13%, a similar error applies to batches of a given weight. Pooling of three adjacent weights results in an increase to 15%. The data obtained from this assay give a measure of the error introduced into a hatching test and enable the experiment to be designed

to any given degree of precision : thus if the figure of 15% error in eggs per batch be applicable, five-fold replication will reduce this to approximately 7%; with ten-fold replication the error will be 5%, etc.

A further test is concerned with estimating the total number of "hatchable" larvae present per batch of cysts and the additional errors introduced into an experiment by the actual hatching procedure. It is also possible to estimate the strength of the diffusate used and for this 180 batches of cysts are required. A sample of the stock diffusate is successively diluted to give a geometric series of dilutions—a factor of four is convenient, giving a series 1 : 1, 1 : 4, 1 : 16, 1 : 64, 1 : 256, 1 : 1024, 1 : 4096, 1 : 16384, followed by a tap water control. Twenty batches of cysts are set up in each dilution and subcultured at weekly intervals for three weeks, the larvae being counted after each "subculture". After three weeks the residual eggs are counted. The data give an estimate of the hatch which has occurred at the end of one, two and three weeks. Provided the cysts used are in good condition the emergence at the end of one and two weeks should be about 50–60% and 75–80% respectively of that at the end of three weeks and, if both cysts and diffusate are satisfactory, the emergence at three weeks should be equivalent to about 80% of the total egg content. Analysis of data for larval emergence gives estimates of the variability to which the results are subject. Usually they are about 40% for first week counts, and 20–30% for second and third week counts.

The data thus obtained enable conditions to be laid down for the conduct of future tests. Should the rate of hatching in these be very different from this pattern, then modifications can be made in the time scale of future experiments but the possibility of the cysts being abnormal or of the diffusate being inactive should not be overlooked. An estimate of the activity of the stock diffusate can be obtained and the limits between which it is possible to interpret a hatching test determined. The cumulative data at the end of three weeks for each dilution are plotted against dilution, (Fenwick, 1952). If the diffusate is fully active and the cysts are behaving normally, then the curve obtained will be divisible into two or three regions (see graph). An upper curved region AB which, with a very active diffusate may completely flatten, a sloping portion BC, and a lower flat area CD which extrapolates to the spontaneous hatch in water. Fenwick (1950) has shown that a straight line could be fitted to the middle portion BC which when produced downwards



A DIFFUSATE DILUTION HATCHING CURVE

cuts the line for water hatch at E. Although this linear relationship is only approximate the curve probably being a sigmoid, it is possible to use the linear part for assaying the diffusate and the curve is first studied to decide the points between which the linear relationship holds. These points set the limits between which results can be interpreted for the particular cysts in use. Having plotted this linear relationship, the L.A. value of the stock diffusate is read off (Fenwick, 1952). Provided the diffusate has been collected as described, an L.A. value of 3·4–3·7 should be obtained and there should be some evidence of the curve flattening out with the more concentrated solutions. A value below 2·5 or a flattening of curves below L.A. 2·5–3·0 both indicate some fault in the method of diffusate production and collection.

The Conduct of Hatching Tests

The results of the preliminary assays govern the conduct of a series of tests on the activities of unknown samples of diffusate or of hatching factor prepared by chemists. The data on variability enable the tests to be carried out to predetermined limits of error. If variability estimates are of the same magnitude as those given above, i.e. $\pm 40\%$ at one week and $\pm 25\%$ at three weeks, then an experiment in five-fold replication will give results subject to an error of $\pm 17\%$ at one week and $\pm 10\%$ at three weeks : in ten-fold replication the errors will be about $\pm 13\%$ and $\pm 8\%$ respectively. Degree of replication for other levels of error can be estimated by calculation. If hatching rates are comparable with those mentioned above, a count is made after the one week "subculture" to give a preliminary result corresponding roughly to the hatch at the point of inflection of the hatching curve ; the larvae from the second and third week "subculture" are counted together, adding the result to the one week data to give an estimate of about 80% of the final hatch if the test is taken on to completion. If either variability or hatching rates are different from those mentioned above then the degree of replication or the time scale will need modification but this is rarely necessary. The straight, middle portion of the dilution curve shows the limits between which the data can be interpreted. These points decided, a test can be set up and should be in two sections. Firstly, a sample of the stock diffusate set up in a geometric series of dilutions, normally a range of 1 : 1 to 1 : 1024, together with a water control is sufficient. Secondly, alongside this series are put up the unknown samples. A minimum of three dilutions, again in geometric intervals of four is desirable. Ideally these should give activities which fall within the linear limits of the hatching

curve. Presoaked cysts are set up in these dilutions and "sub-cultured" at weekly intervals. Counts are made at one week and three weeks (unless the preliminary tests indicate otherwise).

Interpretation of Results

Interpretation of the data falls into two parts : (a) the estimation of the activity of the samples tested and (b) the analysis of the data to verify that the levels of accuracy obtained in the preliminary assays still apply. Provisional estimates of both can be obtained from the data on the seventh day but these must be treated with caution and confirmed by the final counts at the end of three weeks. The procedure for "seven day" and "three week" data is the same : the total emergence for each set of replicates in the stock diffusate series is computed and plotted against dilution. This enables the L.A. value of the stock, as estimated in the preliminary assay, to be verified and gives further information on the limits between which the linear relationship holds. The total emergences in the test series are computed and plotted ; the relationship should be linear and the regression line obtained should be parallel with the assay curve for levels of larval emergence within its limits of linearity. If the curves are not parallel some complicating factor is present such as inhibitors in the test sample, in which case interpretation is impossible. The L.A. values of each dilution can be read off directly on the assay curve. Direct interpolation is possible only within the limits of linearity : if all the data for larval emergence in a test series are outside these limits, further tests at different dilutions are necessary, especially where only one dilution of a test sample can be put up, because the L.A. value is then dependent on one set of readings only and ideally this should correspond more or less with the midpoint of the assay curve. As the L.A. value is a logarithmic estimate of concentration, it is possible to obtain estimates of the concentration of active principle in different samples. Thus, if two samples differ in L.A. values by 1·0, then one is ten times as concentrated as the other. Usually it is sufficient to plot curves by eye, although better estimates can be obtained by calculation ; where a set of tests are being made against a standard stock of diffusate, a common slope can be computed for the standard and unknown alike (Fenwick, 1952).

The levels of accuracy throughout the test are next investigated to confirm previous estimates of error and to test the significance of differences in L.A. values. These are done using normal statistical procedure. The tests and statistical considerations underlying the methods herein described will form the subject of another paper.

Summary

The general principles underlying the conduct of hatching tests are described. Methods for collection of material, and for its preliminary assay are described; the information gained in this way is then used in designing hatching tests. The interpretation of the data resulting from such tests is described and limits are set between which interpretation is possible.

Acknowledgments

The authors take this opportunity to thank a number of assistants who over the last few years have rendered invaluable help with the extremely arduous routine involved. Thanks are also due to the Agricultural Research Council under whose auspices this work was done.

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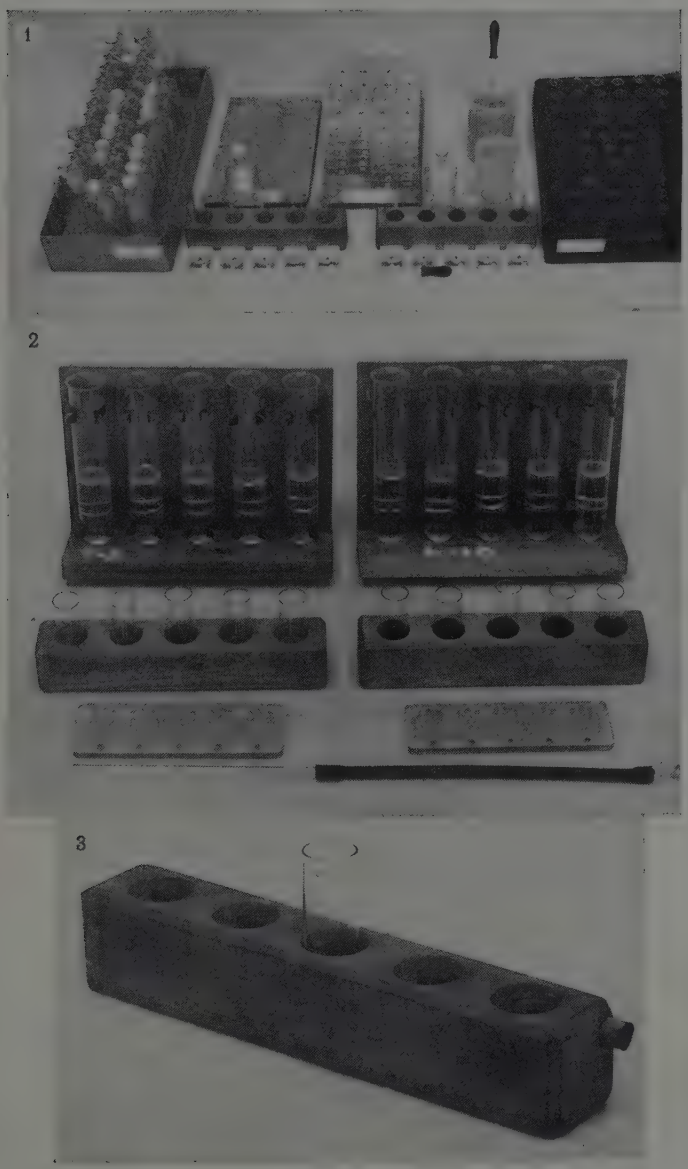

PLATE I

Fig. 1. The bench arrangement for "subculturing" a hatching test. Fig. 2. The bench arrangement for larval counting. Fig. 3. The wooden block for holding the 3 in. × 1 in. tube of larval suspension.

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Observations on Giant Cells in Potato Roots Infected with *Heterodera rostochiensis*

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Although giant cell formation is a characteristic feature of roots infected with parasitic eelworms, the situation and origin of these cells has been little studied. Thus for potato root eelworm (*Heterodera rostochiensis* Wollenweber), both Filipjev and Schuurmans Stekhoven (1941) and Franklin (1951) reproduce the same figure of giant cells from O'Brien and Prentice (1930). This figure, which is in a general paper on potato root eelworm and not in one devoted solely to giant cells, shows a transverse section of a relatively old root (45 days after planting) with considerable secondary thickening and in which there is a nearly mature female eelworm. Sections of younger roots were apparently not studied by O'Brien and Prentice, and it is therefore not possible from their work to ascertain in which tissue or tissues giant cells are first formed. The present investigation was undertaken especially to study early stages in giant cell formation.

Material and Methods

Small, sprouted tubers of the variety Majestic were grown in pots of a black fen soil from Feltwell, Thetford, Norfolk. This soil had a very high viable cyst content which had been built up by growing Majestic in it for two years. Portions of roots were fixed, 14, 21, 28, 35 and 45 days after planting. The fixative used was CRAF (Randolph, 1935). After fixation the roots were washed in water and stored in 70% alcohol in a refrigerator at about +5°C until required for sectioning.

To ensure that the material to be sectioned did contain eelworm larvae, the pieces of root were immersed in Fleming's solution for about 12 hours. This stains the larvae black. Pieces of roots containing larvae were then embedded in wax by the chloroform method and sectioned transversely at 20μ. The slides were stained by the iodine-gentian violet method. The diagrams were made by tracing microphotographs.

Anatomy of Potato Roots

Potato roots have the typical dicotyledonous anatomy (Artschwager, 1918; Hayward, 1938). They are either triarc or tetrarc with three or four primary xylem groups respectively (Fig. 1). The endodermis, which may be considered as the boundary between the cortex and the central vascular strand, can be recognised in most sections by the Casparian strips on its radial walls and by the inner tangential walls being thickened a little (Fig. 1). Inside the endodermis there is a pericycle which is one cell thick in transverse section. Contrary to the statement in Artschwager (1918), the pericycle does occur next to the xylem groups, and the protoxylem does not abut directly on the endodermis. The cells of the pericycle adjacent to the protoxylem are somewhat larger than those adjacent to the primary phloem groups (Fig. 1). The phloem group consists of cells which in transverse section are relatively small. Between the xylem and phloem groups are parenchyma cells; these parenchyma cells of the central vascular strand, as will be described later, comprise one group of cells which can develop into giant cells.

Lateral roots originate in the pericycle on the outside of the protoxylem groups (Fig. 1). Secondary thickening occurs from a cambium which is produced first in the parenchyma cells interior to the phloem groups and which becomes continuous, the last part formed being in the pericycle exterior to the primary xylem groups. The first formed secondary xylem is on the inside of the primary phloem groups. Secondary thickening leads to the primary phloem being crushed, and in sections of older roots the primary phloem cannot always be seen or distinguished from the secondary phloem (Artschwager, 1918; Hayward, 1938).

Giant Cell Formation

A—Early stages (roots fixed 14 *and* 21 *days after planting).*

Larval tracks but no traces of giant cell formation were found in three of the five portions of root sectioned from material fixed 14 days after planting in the eelworm infested soil. However, in two other portions some indications of giant cell formation were seen. The initiation of giant cell formation would thus seem to occur soon after larval invasion. Fig. 2 is a diagram of one of the sections which appear to show the first stages in giant cell formation. It can

be seen first that one cortical cell is considerably enlarged and has somewhat more dense contents than the other cells. Secondly one endodermal cell is stretched tangentially, and three cells of the pericycle are considerably enlarged. Thirdly there is also some indication that some enlargement has occurred in about five outer cells of the parenchyma tissue between the protoxylem and the primary phloem. These parenchyma cells cannot, however, at this stage of enlargement be definitely classified as potential giant cells, but they may on the other hand represent an early stage in giant cell formation. In sections of the other piece of root, two groups of three pericycle cells each showed enlargement, and the cells were apparently in the process of becoming giant cells.

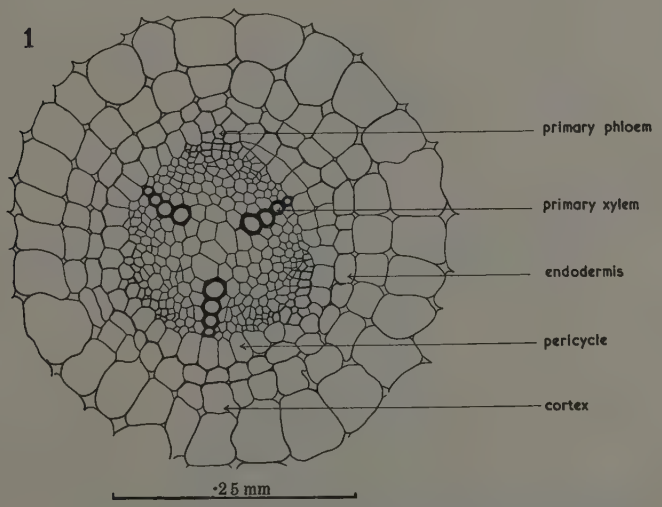


Fig. 1. Transverse section of normal potato root, central vascular strand and two cell layers only of cortex shown (×145). Triarc root. Pericycle cells at 2 o'clock dividing to form a meristem which would grow into a secondary root. For further descriptions, see text.

Only two pieces of root from material fixed 21 days after planting in infested soil were sectioned. Both gave similar sections, good giant cells being seen in the cortex, endodermis and pericycle. There was some enlargement of the parenchyma cells between the primary xylem and primary phloem groups, but none of these cells could be definitely recognised as being giant cells.

B—Later stages (roots fixed 28, 35 and 45 days after planting).

Five pieces of root from the material fixed 28 days after planting in eelworm-infested soil were sectioned. In one piece giant cell formation appeared to be confined to the pericycle and parenchyma cells of the vascular strand between the primary phloem and xylem groups (see Fig. 3). In the other four pieces a conspicuous feature of some sections was the formation of giant cells in the cortex (see Fig. 4). Investigation of all the sections, however, showed that

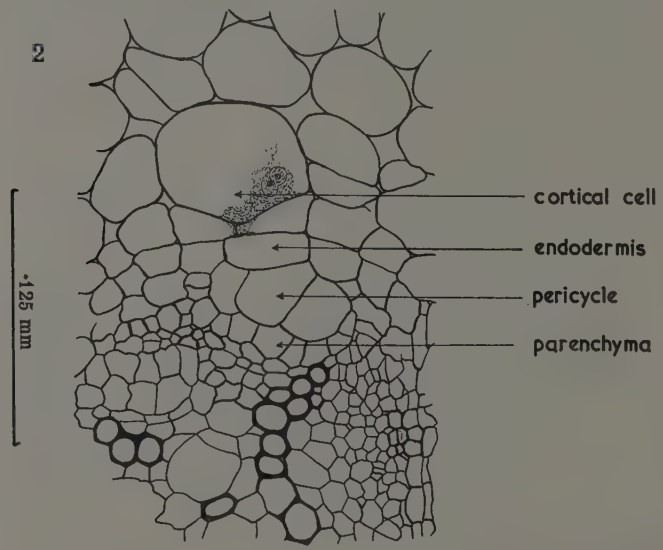
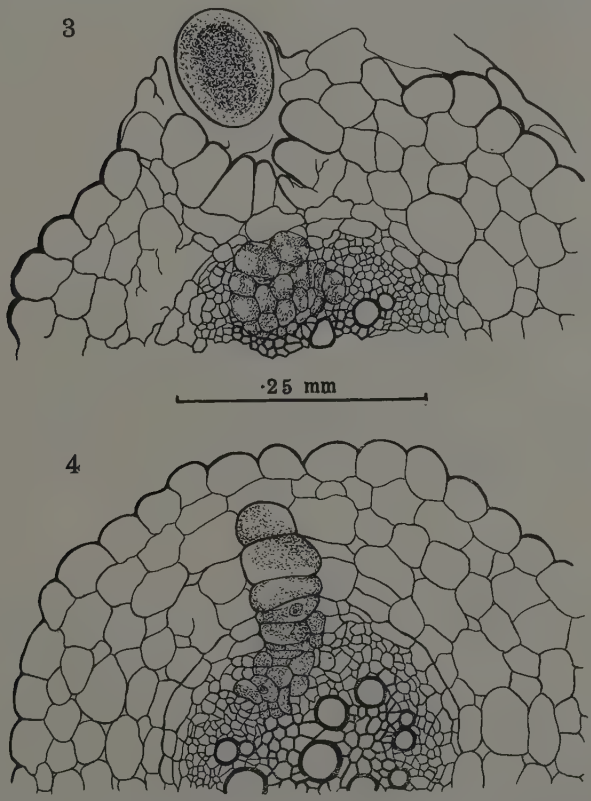


Fig. 2. Transverse section of portion of a root fixed 14 days after planting in eelworm infested soil (×320). A single cell each of the cortex and of the endodermis, three pericycle cells and about five cells of the parenchyma between the protoxylem and the protophloem are enlarged.

giant cell formation was much less frequent in the cortex than in the pericycle and in the parenchyma cells of the vascular strand. It was found that giant cells in the cortex only occurred near the head of an eelworm, and that they did not occur in the cortex in the sections of root nearer to the root tip where the main part of the eelworm was (Figs. 3 and 5). In the latter sections it was only the cells of the pericycle and of the parenchyma between the xylem and phloem groups which had developed into giant cells.

The giant cells in the cortex (Fig. 4 and see also Fig. 5) are noteworthy in that they always occur along one radius and are never more than one cell wide tangentially. There appears to be no obvious explanation of this typical and constant feature. The



Figs. 3 and 4. Transverse sections of same portion of root fixed 28 days after planting in eelworm infested soil (×150). Fig. 3 contains an immature cyst and Fig. 4 is from just above the head of the eelworm. All giant cells have granular contents.

development of giant cells from the parenchyma cells of the vascular strand leads in those sectors of the root where it occurrs to no cambium being produced and hence to no secondary xylem. The vascular strand therefore appears to have an irregular structure. This irregular

appearance is, however, probably not due to giant cell formation deforming other tissues, but only to the absence of secondary xylem elements in those sectors where the giant cells are.

Two sets of sections were studied of material fixed 35 days after planting in infested soil. In one set of sections giant cell formation was seen to have occurred from cortical, endodermal, pericycle and vascular parenchyma cells (Fig. 5), but in a second set no giant cell formation had occurred in the cortex. As in the 28 day material, the giant cells in the cortex are on single radii, only one cell wide tangentially and contiguous. Also, again as in the 28 day material, all the parenchyma cells in some sectors of the central vascular strand have developed into giant cells.

One feature of the sections of the roots fixed 45 days after planting in infested soil was the considerable degree of apparent distortion found in the central vascular strand. Thus, in the place of an almost complete ring of secondary xylem, sections with two groups of secondary xylem separated by two groups of giant cells were formed. The apparent distortion is no doubt greater than in younger material because more secondary xylem has been formed in those sectors where no giant cells occur. In other respects the 45 day sections were similar to those figured for the 28 and 35 day material.

Discussion

The observations recorded in the previous section are not quite full enough for a complete account of giant cell formation in eelworm-infected potato roots to be given. They do, however, show that giant cell formation, although it is mainly in the later stages from the parenchymatous cells of the central vascular strand as is shown in the figure of O'Brien & Prentice (1930), may also be from cortical, endodermal and pericycle cells. The observations on roots fixed 14 and 21 days after planting in infested soil would, in fact, seem to suggest that the first formed giant cells develop in the cortex and pericycle.

It was not possible from the transverse sections studied to ascertain exactly how many cells deep in longitudinal section of the various tissues become giant cells. It appeared that giant cells were only one cell deep in the cortex, but that they occurred for from four to six cells deep, in the parenchyma of the central vascular

strand. Good longitudinal sections, which appear to be rather difficult to obtain and interpret, would be useful for deciding this and some other features. The fact that the giant cells in the vascular parenchyma appear to be from four to six cells deep is not surprising because these cells, if they had not become giant cells, would have formed secondary xylem vessels in which the end cell walls disappear.

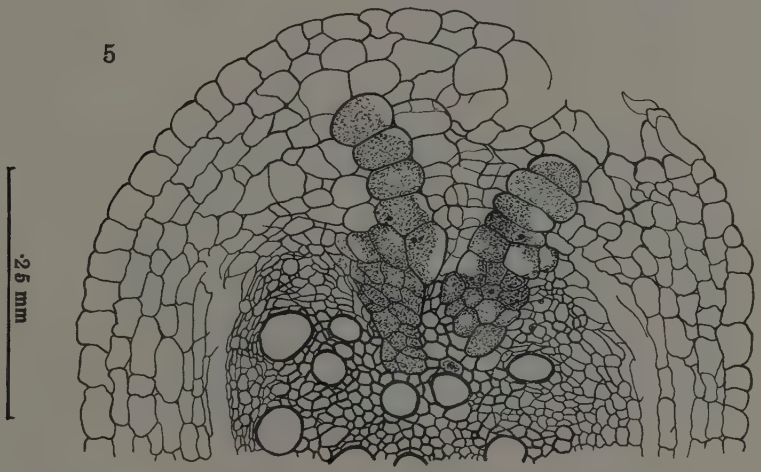


Fig. 5. Transverse section of portion of root fixed 35 days after planting in eelworm infested soil (×150). The two groups of giant cells are due to two eelworms. All the giant cells have granular contents, and in the central vascular strand they extend from a primary xylem group to the phloem groups on either side of it.

It is suggested by O'Brien and Prentice (1930) that the eelworm larvae come to rest in the cortex with their heads abutting on the endodermis, and that they feed from cells in the central vascular cylinder, their salivary secretions causing the cells to enlarge and become giant cells. The present observations would suggest that they also feed from cortical cells. The fact that the pericycle cells may be the first cells of the vascular strand to enlarge is presumably due to these being the first cells to be reached in the vascular strand by the eelworms. The non-enlargement of the primary phloem cells, which is a conspicuous feature of all the sections, may be due to the larvae not feeding from these relatively small cells, but it could also be due to the possibility that the phloem cells are not capable of enlarging.

According to Nemec (1933) the giant cells in beet roots infected with *Heterodera schachtii* may become multinucleate due to the breakdown of cell walls. A breakdown of cell walls in transverse section was apparently rare in the potato giant cells seen in the present study, but it did appear to have taken place in at least one of the sections (Fig. 6). It may be significant that this section is from the 45 day material and not from the younger roots.

Fig. 6. Details of giant cells in portion of root fixed 45 days after planting in eelworm infested soil (×300); a multinucleate cell and the breakdown of cell walls can be seen.

Another feature of giant cells, which has not been studied, is the constitution of their cytoplasm which, in contrast to that of normal cells, appears to contain many granules (see Figs. 3, 4, 5 and 6). There was also some indication that the nuclei in giant cells are somewhat larger than those in normal cells.

It is usually considered that the macroscopic features of eelworm attack on potatoes—a marked tendency of the plants to wilt; brown, necrotic patches at the tips of leaflets; death of roots—are due both to the injury caused when the eelworms enter the roots and to the disturbance of the translocation system caused by the formation of giant cells. As seen in transverse sections, the damage caused by giant cell formation does not appear to be very large.

Some of the secondary xylem is not produced in the sectors where the giant cells occur, but there are still masses of well developed secondary xylem in the other sectors. It might, however, be that longitudinal sections would indicate more damage because the sectors in which no secondary xylem is produced by the many eelworms found in a heavily infected root are on different as well as on the same axes. Thus, unless radial transport occurs readily, considerable resistance to the transport of water will be produced because there are no long stretches of uninterrupted vessels.

Summary

1. Giant cell formation was studied in the roots of potatoes grown in a soil infested with *Heterodera rostochiensis*.

2. Some indication of giant cell formation was found in roots fixed 14 days after planting of sprouted tubers in the infested soil.

3. Giant cells may be formed by the cells of the cortex, the endodermis, the pericycle and the parenchyma cells of the central vascular strand.

4. The first giant cells appear to be formed in the cortex and pericycle.

5. Giant cells in the cortex are only found near the head of an eelworm.

6. Giant cell formation by the parenchyma cells of the central vascular strand leads to no cambium and hence no secondary xylem being produced in those sectors of the root where they occur.

7. The occurrence of sectors of the root in which there is no secondary xylem gives the central vascular strand an irregular appearance.

8. Some giant cells may be multinucleate. They all have granular cytoplasm.

Acknowledgment

Our thanks are due to Mr. V. Chapman for taking the microphotographs which were used in the preparation of the figures.

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On Some Trematodes from the Manicou, *Didelphis marsupialis insularis* (Allen) from the West Indies

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During 1932, Professor J. J. C. Buckley examined over fifty specimens of the manicou, *Didelphis marsupialis insularis* (Allen) from various places in Trinidad, British West Indies. The helminths recovered were preserved in 70% alcohol and 5% glycerine. This material, Professor Buckley very kindly placed at my disposal. Three species of trematodes were recovered, viz : *Achillurbainia recondita* Travassos, 1942 ; *Metadelphis evandroi* Travassos, 1944 ; *Rhopalias coronatus* (Rudolphi, 1819) Stiles and Hassell, 1898. It is interesting that in no case was the one opossum infested with more than one of these species of trematode. Descriptions are given for all three species, emphasis being placed on new features, or those varying from earlier descriptions.

Achillurbainiidae Dollfus, 1939

Achillurbainia Dollfus, 1939

There are only two previous records of this genus, viz : *Achillurbainia nouveli* Dollfus, 1939, described from a black panther, *Felis pardus melas* L., from Malaya, and *Achillurbainia recondita* Travassos, 1942, from the maxillary sinus of the opossum, *Didelphis marsupialis* from Ubatuba, São Paulo, Brazil. Eleven specimeus of *A. nouveli* were recovered from a palpebro-orbital abscess in the panther.

From the present collection, only one specimen was recovered from *Didelphis marsupialis insularis* (Allen), from Rio Claro, Trinidad. Unfortunately, there is no definite information on the location in the host from which it was collected, but it appears to have been from the intestine of its host.

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In the following description, the measurements were made from the one specimen stained in acetic-alum-carmine and mounted in canada balsam.

Achillurbainia recondita (Fig. 1)

The body is oval, relatively wide and thick, 8·0 mm. long, with a maximum width 3·2 mm. immediately behind the middle of the body length.

The oral sucker is ventral, slightly subterminal, 0·56 mm. long, 0·70 mm. wide. The acetabulum, which is 0·77 mm. in diameter, is almost at the middle of the body length. The ratio of the oral sucker length to the ventral sucker length is 1 : 1·19. Longitudinal nerve cords are well developed; three pairs pass posteriorly from the pharyngeal region. The pharynx is 0·38 mm. diameter; the oesophagus is 0·21 mm. long and bifurcates 1·05 mm. from the anterior end of the body. The wide and sinuous intestinal crura pass almost to the posterior extremity of the body.

The testes are follicular, appearing to lie mostly between the vitelline fields. Each testicular follicle is of approximately equal size to the vitelline follicles, varying from 0·04 to 0·08 mm. diameter, but usually being 0·06 mm. The testicular follicles are not all well defined, which may be due to uneven staining.

The ovary is spherical with an entire margin, 0·62 mm. diameter, lying to the right of the midline of the body about halfway along its length. Mehlis' gland is distinct, measuring 0·28 × 0·21 mm. The vitellarium extends from 0·9 mm. from the anterior end of the body to its posterior extremity. The spherical or subspherical follicles are arranged in groups mainly in the two lateral fields of the body. These groups form distinct patterns, both on the dorsal and ventral surfaces of the body, the follicles at the edges being markedly smaller. The follicles on the dorsal and ventral surfaces are from 40μ × 60μ to 70μ × 100μ: the follicles in the extreme lateral fields are more closely compacted averaging 30μ diameter. Many of the small vitelline ducts as well as the main longitudinal ducts are evident. The transverse vitelline ducts are immediately behind the ovarian and uterine field. The uterus forms tight coils anteriorly to the ovary. The ventral genital pore is about midway along the length of the oesophagus. The uterus is filled with numerous operculate eggs 70μ × 40μ (Fig. 2).

This trematode is identified as *Achillurbainia recondita* Travassos, 1942, since the testicular follicles are of approximately the same size as the vitelline follicles.

Achillurbainia nouveli and *A. recondita* are very closely related. They have the same general appearance, and a common size range. The specimen described here is of slightly smaller body length and width (Table 1). Travassos separated *A. recondita* on the basis of testicular follicle size, 40μ–80μ diameter; they are the same size as the vitelline follicles. In *A. nouveli*, they are 120μ to 280μ diameter, and distinctly larger than the vitelline follicles.

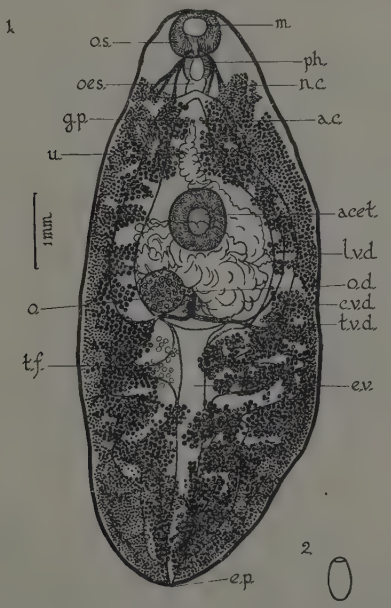


Fig. 1. *Achillurbainia recondita* Travassos, 1942. Whole specimen.
Fig. 2. *Achillurbainia recondita* Travassos, 1942. Egg.

It is interesting that the only two recorded species of this genus were recovered from unusual locations in their hosts, viz : a cephalic abscess, and the maxillary sinus. Until further records have been made, nothing can be satisfactorily deduced about the relationship

TABLE 1

Comparison of *Achillurbainia* species

Species	*A. nouveli* Dollfus, 1939	*A. recondita* Travassos, 1942	*A. recondita* Present record
Host	*Felis pardus melas*	*Didelphis marsupialis*	*Didelphis marsupialis insularis*
Distribution	Malaya	Ubatuba, Brazil	Rio Claro, Trinidad
Body Length	9·5–11·0 mm.	9·6–11·2 mm.	8·0 mm.
Maximum body width	4·5–6·0 mm.	3·5–5·2 mm.	3·2 mm.
Oral Sucker	0·75 mm. long × 0·88 mm. —0·95 mm. long × 1·00 mm.	0·64–0·76 mm.	0·56 mm. long × 0·70 mm.
Ventral Sucker	0·75 mm. long × 0·88 mm. —0·95 mm long × 1·00 mm.	0·85–0·99 mm. dia.	0·77 mm. dia.
Sucker Ratio	1 : 1–1 : 1·25	1 : 1·25	1 : 1·19
Ovary	0·63–0·92 mm. dia.	0·68–0·88 mm. dia.	0·62 mm. dia.
Testicular Follicles	0·12–0·28 mm.	0·06–0·13 mm.	0·04–0·08 mm.
Vitelline Follicles	0·05–0·09 mm.	0·06–0·13 mm. dia.	0·06–0·08 dia. or 0·06 × 0·08 mm.
Eggs	55–60μ × 32–34μ	64–72μ × 38–45μ	70μ × 42μ

of the Achillurbainiidae, which Dollfus considered to be "the least furthest away from the Paragonomidae".

The specimen identified as *Achillurbainia recondita* Travassos, 1942, collected from *Didelphis marsupialis insularis* (Allen) from Rio Claro, Trinidad, has been lodged in the helminthological collection of the Parasitology Department of the London School of Hygiene and Tropical Medicine.

DICROCOELIIDAE Odhner, 1910

Metadelphis Travassos, 1944

Metadelphis evandroi Travassos, 1944, from the gall bladder of *Didelphis marsupialis marsupialis* L., from Aura, is the only previous record both for the genus and species.

Examination of helminths recovered from over fifty specimens of *Didelphis marsupialis insularis* Allen, from the West Indies, showed that five hosts were infested with dicrocoeliids in the gall bladder. They were from Grancouva and Sangre Grande, Trinidad. The infestations numbered 29, 19, 15, 7, 2 flukes respectively. They have been identified as *Metadelphis evandroi* Travassos, 1944, although they are all smaller than in the original description (Table 2).

Whole specimens were stained in acetic-acid-alum-carmine and mounted in Canada balsam ; sections were stained in Ehrlich's haematoxylin and eosin. Measurements were made from twenty whole mounted specimens.

Metadelphis evandroi Travassos, 1944 (Figs. 3–6)

The total body length is 2·5–3·76 mm.; the maximum width 0·4–0·75 mm. is always towards the posterior end of the body across the field occupied largely by uterine coils. It is usually posterior to the vitelline fields. Anteriorly, the body bears very fine cuticular spines, especially evident dorsally and around the mouth opening (Fig. 4). The subventral oral sucker may be circular ; when oval, it is 0·14–0·20 mm. × 0·11–0·17 mm., the greater measurement always being lengthwise. The acetabulum also varies in shape being 0·15–0·21 mm. in diameter or 0·14–0·22 mm. × 0·14–0·21 mm. However, the variation in the shape of the acetabulum may be due to preservation, since its greater measurement may be either the length

TABLE 2

Comparison of *Metadelphis evandroi* specimens

	Body length	Maximum body width	Oral Sucker: Acetabulum Ratio	Testes	Ovary	Vitelline Fields	Eggs
Metadelphis evandroi Travassos, 1944	4·3–5·4 mm.	1·3–1·5 mm.	1 : 1·13–1 : 1·15	0·30–0·50 mm. × 0·60–0·80 mm.	0·19–0·26 mm. × 0·40–0·52 mm.	1·16–1·68 mm.	0·030–0·034 mm. × 0·020–0·022 mm.
Metadelphis evandroi present specimens	2·5–3·78 mm.	0·4–0·75 mm.	1 : 1·1–1 : 1·5	ant. 0·21–0·29 mm. × 0·18–0·35 mm. post 0·21–0·42 mm. 0·2–0·28 mm.	0·14–0·28 mm. × 0·10–0·31 mm.	0·5–1·4 mm.	0·03 × 0·01

or the width. The ratio of oral sucker length to ventral sucker length is 1 : 1·1 to 1 : 1·5, the most usual ratio being 1 : 1·1 to 1 : 1·2.

The mouth is ventral and subterminal ; no pharynx is evident ; the alimentary canal bifurcates at approximately the level of the cirrus pouch. The intestinal crura pass almost to the posterior extremity of the body.

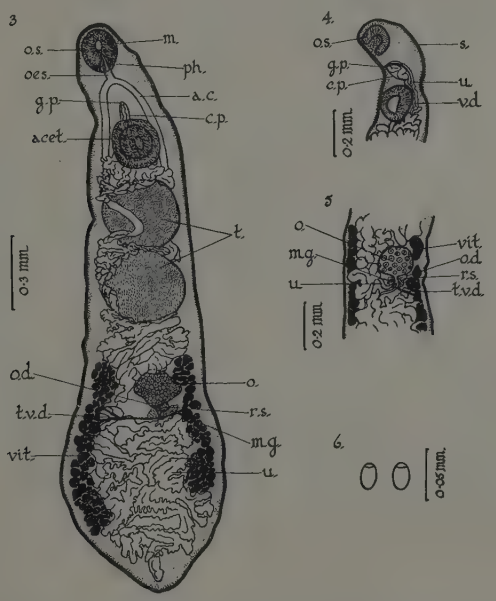


Fig. 3. *Metadelphis evandroi* Travassos, 1944. Whole specimen.
Fig. 4. *Metadelphis evandroi* Travassos, 1944. Side view of anterior end.
Fig. 5. *Metadelphis evandroi* Travassos, 1944. Horizontal section to show details of the genital complex.
Fig. 6. *Metadelphis evandroi* Travassos, 1944. Eggs.

The testes are spherical or subspherical either with an entire margin or lobed. They lie in tandem towards the posterior region of the anterior half of the body, and are separated from the acetabulum by uterine loops. The diameter of the anterior testis is 0·21 to 0·35 mm.; if subspherical it is 0·21 to 0·29 mm. long × 0·18–0·35 mm. The posterior testis is 0·25 to 0·39 mm. diameter,

or 0·21 to 0·42 mm. long × 0·2 to 0·28 mm. The cirrus pouch is well developed, and contains the seminal vesicle (Fig. 4). The genital pore is on the mid-ventral line anterior to the acetabulum.

The ovary is spherical or subspherical, lies to the left of the midline of the body, and posterior to both testes, being separated by loops of the uterus. It has an entire margin. When spherical, it is 0·14 to 0·28 mm. diameter, and in other specimens, it is 0·10 to 0·31 mm. long × 0·14 to 0·28 mm. The vitellarium is well developed, with comparatively large acini, 0·03 to 0·07 mm. × 0·04 to 0·1 mm. The vitelline fields lie towards the outer edges of the body passing from about the level of the anterior border of the ovary to about halfway along the rest of the body length. They are 0·5 to 1·4 mm. long and may be of equal lengths. If one vitelline field is shorter than the other, the shorter is always on the left side of the body, i.e. on the same side as the ovary. Mehlis' gland is close to the ovary, and is 0·2 to 0·3 mm. diameter. The receptaculum seminis is near Mehlis' gland and is 0·13 to 0·19 mm. × 0·06 to 0·10 mm. The uterus passes posteriorly between the vitelline fields, and coils to fill the entire posterior portion of the body. The uterine pore is immediately anterior to the cirrus opening (Fig. 4). The uterus is packed with small, operculate eggs 0·03 × 0·01 mm. (Fig. 6).

Specimens identified as *Metadelphis evandroi* Travassos, 1944, from *Didelphis marsupialis insularis* Allen, from Grancouva and Sangre Grande, Trinidad, have been lodged in the helminthological collection of the Department of Parasitology, London School of Hygiene and Tropical Medicine; in the British Museum; and in the Queensland Museum, Brisbane.

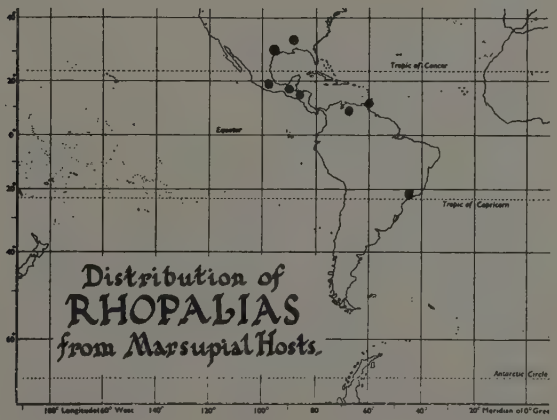
Rhopaliidae Looss

Rhopalias Stiles and Hassall, 1898

This genus is restricted to the American marsupials. There are four species, viz: *Rhopalias baculifer* Braun, 1901; *R. coronatus* (Rudolphi, 1819), which is the most common species with the widest distribution: *R. horridus* (Diesing, 1850); *R. macracanthus* Chandler, 1932.

Rhopalias baculifer has been recorded only once, from *Chironectes minimus* from Brazil, South America.

Rhopalias coronatus has been recorded from several different host species or subspecies in South America. Caballero (1946), extended this range by recording it from Guatemala, Central America, and Chiapas, Mexico. These host records are : *Chironectes minimus, Didelphis marsupialis aurita, Didelphis marsupialis karkinophaga, Didelphis virginiana, Metachirus nudicaudatus* and *Metachirus opossum* all from Brazil ; *Didelphis mesamericana mesamericana, Marmosa mexicana mexicana* from Central America ; *Didelphis marsupialis karkinophaga* from Trinidad ; *Didelphis marsupialis* from Venezuela ; *Didelphis mesamericana tabascensis* from Mexico.



Rhopalias horridus has been recorded from *Didelphis marsupialis aurita, Metachirus nudicaudatus, Metachirus opossum* and *Philander philander* from Brazil, South America ; from *Didelphis marsupialis* from Venezuela and from *Didelphis mesamericana mesamericana* from Central America.

Rhopalias macracanthus has been recorded only from Northern America. It was described by Chandler (1932) from *Didelphis marsupialis virginiana* from Texas. Caballero (1946) also recorded *Rhopalias macracanthus* from *Didelphis mesamericana tabascensis* from Mexico.

Rhopalias sp. has been recorded from *Didelphis marsupialis virginiana* from Louisiana, North America.

The distribution of these species is interesting. *Rhopalias coronatus*, occurring in a very wide range of marsupial hosts, is well established in South America, particularly Brazil, and extends up into the southern part of North America. *R. baculifer* is also present in Brazil, being recorded from *Chironectes muris*, which is also a host for *Rhopalias coronatus*. *R. horridus* has a similar distribution to *R. coronatus*, but occurs in different hosts, having only one in common, viz : *Metachirus nudicaudatus*. The *Metachirus opossum* recorded may also be a common host. *Rhopalias macracanthus*, the most northerly occurring form, has only one host in common with *R. coronatus*, viz : *Didelphis virginiana*. The distribution of *Rhopalias* is shown in the map.

Rhopalias coronatus (Rudolphi, 1819) (Plate I, Figs. 1–4)

Specimens were recovered from the intestines of seven of over fifty specimens of the manicou *Didelphis marsupialis insularis* from the West Indies. These infestations numbered 19, 11, 4, 4, 3, 2, 1 flukes respectively. They were from hosts from Rio Claro, Tacarigua and Maracas, Trinidad.

All the specimens were measured ; some were stained with acetic-alum-carmine and mounted in Canada balsam. Sections were cut at 5μ and stained in Ehrlich's haematoxylin and eosin. Measurements of body structures were made from stained mounted specimens.

The following full description is given as it increases the range in various measurements already recorded for this species, and adds some new details. The sections appear to be the first illustrated from this genus.

The body tapers towards the tail ; there are two distinct regions, the anterior being expanded and broader than the posterior, this division occurring immediately behind the acetabulum (Plate I, Fig. 1). The total body length is 2·75–10·0 mm., the anterior region of the body being 0·75–3·0 mm. long. The ratio of the anterior body to the posterior body is 1 : 3 to 1 : 9, the average being 1 : 4. The maximum width of the anterior body is 0·5–1·5 mm., and of the posterior body 0·5–1·5 mm., the anterior body is heavily covered with regularly arranged cuticular spines 0·03 mm. long which extend on to the anterior of the posterior body region and passing backwards rapidly decrease in number. There are only occasional scattered cuticular spines behind approximately the first sixth of the length of the posterior body. In some specimens, the cuticular spines had completely disappeared ; this is doubtlessly due to preservation.

The two proboscis sacs are comparatively long ranging from 0·98 to 1·4 mm., and being 0·21–0·29 mm. wide ; they extend posteriorly to the pharynx. They are armed with spines, 60μ–70μ long × 20μ wide. There are three distinct groups of spines on the extreme anterior end of the body between the proboscis sacs, measuring 60μ–70μ in length (Plate I, Fig. 3).

The oral sucker is sub-ventral, sub-circular or circular, 0·21–0·28 mm. long × 0·20–0·28 mm. wide. The acetabulum is muscular and broadly oval, 0·60–0·91 mm. long × 0·49–0·84 mm. wide. The ratio of the oral sucker length to the acetabulum length is 1 : 3. The prepharynx is 0·07 mm. long ; the pharynx is 0·21 mm. long × 0·13–0·14 mm. wide ; the oesophagus is 0·28–0·56 mm. long ; the alimentary canal branches behind the proboscis sacs and anteriorly to the genital pore. The excretory pore lies posterior on the dorsal surface of the body ; the excretory vesicle is large.

The two testes lie in tandem and are elongate of uneven shape situated in the middle of the length of the posterior region of the body, between the lateral vitelline fields. The anterior testis is 0·77–0·7 mm. long × 0·35–0·56 mm.; the posterior testis is 0·63–0·77 mm. long × 0·35–0·56 mm. The cirrus pouch is large, conspicuous and lagena shaped, extending from the anterior of the ovary, curving behind the acetabulum to the genital aperture. (Plate I, Figs. 2 and 3). It is 1·4–1·89 mm. long with a maximum width of 0·35–0·49 mm. across its posterior end. The seminal vesicle is large and lies posteriorly within the cirrus pouch ; the ejaculatory duct is well defined.

The ovary is spherical, 0·3–0·42 mm. diameter ; the oviduct arising from its posterior margin passes backwards. Mehlis' gland is well developed and lies between the anterior testis and the ovary (Plate I, Fig. 4). The receptaculum may be large, oval, 0·2 × 0·14 mm., and is close to Mehlis' gland. The vitelline fields are lateral, the acini varying in size, being spherical, subspherical and often elongate, and presenting a mosaic pattern ; they are 0·07–0·1 mm. diameter and 0·07–0·14 mm. × 0·04–0·07 mm. The vitelline fields extend from the level of the posterior border of the acetabulum to the extreme end of the body, gradually increasing in width until merging immediately behind the posterior testis. The transverse vitelline ducts are in front of the anterior testis. The uterus passes from Mehlis' gland ventrally beneath the ovary, curves around the posterior entremity of the cirrus pouch to the dorsal side and returns to run between the cirrus pouch and the acetabulum opening immediately posteriorly to the cirrus opening (Plate I, Fig. 3). The maximum

TABLE 3

Comparison of *Rhopalias species*

	Body Length	Ratio Anterior Body : Posterior Body	Length of Proboscis Sacs	Ratio Oral Sucker : Acetabulum	Egg Sizes μ
R. baculifer	10–12 mm.	No distinct separation. Very great.	0·28 mm.	1 : 2	93 × 52
R. coronatus	2·75–10 mm.	1 : 2·6–1 : 9	0·56–1·4 mm.	1 : 2·8–2 : 3·5	80–100 × 60–80
R. horridus	2–3 mm.	1 : 3	0·17–0·26 mm.	1 : 1·4–1 : 1·8	?
R. macracanthus	4–4·75 mm.	1 : 5	0·28–0·32 mm.	1 : 2·4	105–110 × 60 dia.

number of eggs observed in the uterus is between one hundred and one hundred and fifty. They are operculate, 80μ–100μ × 60μ.

Comparative features for the species of *Rhopalias* are shown in Table 3.

Specimens identified as *Rhopalias coronatus* (Rudolphi, 1819) from *Didelphis marsupialis insularis* from Trinidad, the West Indies, are lodged in the helminthological collection of the Department of Parasitology, London School of Hygiene and Tropical Medicine ; the British Museum of Natural History, and the Queensland Museum, Brisbane.

General Discussion

Knowledge of the Achillurbainiidae presents a confusing picture of distribution and also of host relationships, since the hosts are a carnivore from Malaya and marsupials from South America. Also, there does not appear to be any constancy in the location in the host where the parasites are found. Until further records are made, nothing can be stated satisfactorily about the geographic distribution of members of the family.

Metadelphis from South American opossums may represent a group of trematodes to be found only in a restricted area from a limited range of hosts. However, if a related species is found in an Australian marsupial, it may well prove to be another example in parallel with that of *Zonorchis*, where *Zonorchis allentoshi* (Foster, 1939) from North and South American marsupials is closely related to *Zonorchis australiensis* Sandars, 1958 from Australian marsupials.

Similarly in *Rhopalias*, a member of a family as yet limited to American marsupials, if it is discovered to be present also in Australian marsupials, it will present another interesting link phylogenetically. In America, *Rhopalias* is well established, occurring in a number of marsupial species and having a wide geographic distribution. The four species of *Rhopalias* are closely related although specifically quite distinct.

Summary

Three new records are made, viz : *Achillurbainia recondita* Travassos, 1942 ; *Metadelphis evandroi* Travassos, 1944 ; *Rhopalias coronatus* (Rudolphi, 1819) Stiles and Hassall, 1898 ; all are recorded from the manicou, *Didelphis marsupialis insularis* (Allen) from Trinidad, British West Indies. Descriptions of all these species are given.

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I wish to express my appreciation to Professor J. J. C. Buckley who generously placed the material described in this paper at may disposal.

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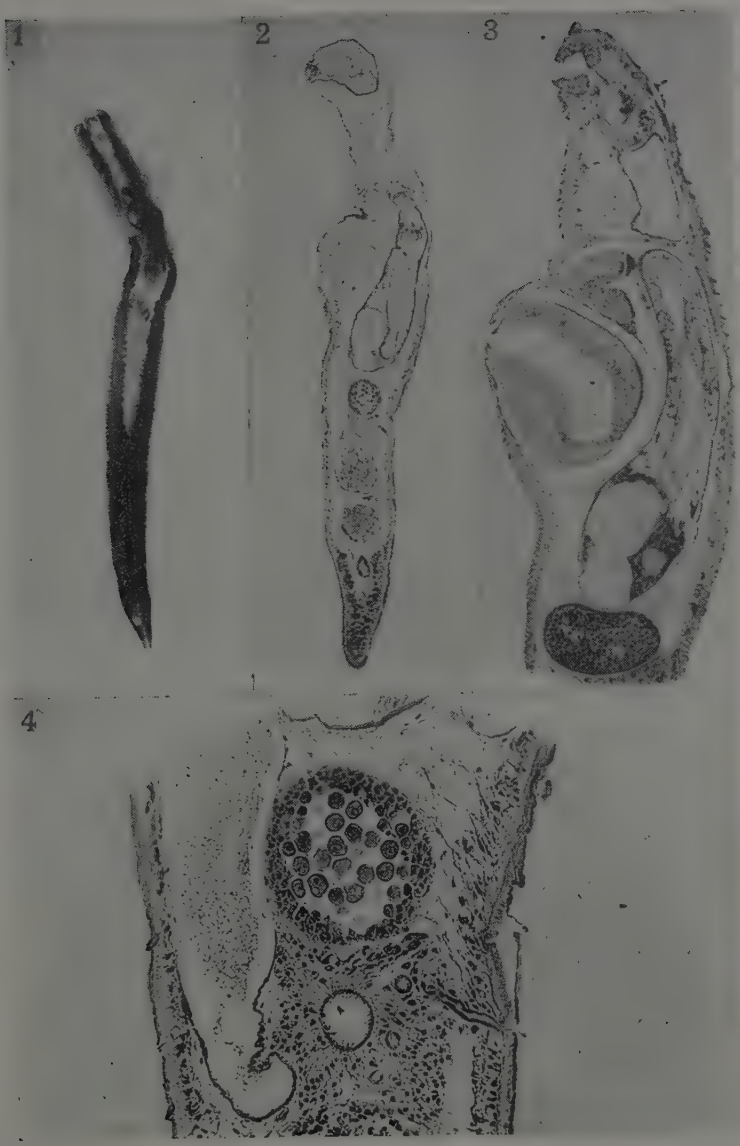

PLATE I

Rhopalias coronatus (Rudolphi, 1819).

Fig. 1. Photograph of whole specimen. Fig. 2. Photograph of sagittal section of entire worm. Fig. 3. Photograph of sagittal section of anterior body showing details of oral sucker, acetabulum, pharynx, oesophagus, cirrus pouch with seminal vesicle and ejaculatory duct. Fig. 4. Photograph of sagittal section of middle of body showing Laurer's canal opening to the dorsal surface, ootype and Mehlis' gland and ovary.

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*Helminth Parasites of Hertfordshire Birds
II.—Cestoda

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*From the Department of Parasitology,
London School of Hygiene and Tropical Medicine*

This paper, the second in the series, deals with the cestodes found during a survey of the helminth parasites of Hertfordshire birds. In all 16 different species were recorded, three of which appear to be new to science. Descriptions of previously reported species are often rather inadequate or misleading. This paper does not attempt to redescribe these species in detail but rather to provide a concise description from which it should be possible to identify further material. All the descriptions in this paper are based on the material collected during the survey, and only compared with previous work if there is a wide discrepancy. It is hoped that these descriptions will provide at least a starting point for future work on the cestodes of Passeriform birds in Great Britain.

Taxonomic position of the species recorded.

Dilepididae Fuhrmann, 1907

Dipylidiinae Stiles, 1896.

Choanotaenia Railliet, 1896

Choanotaenia unicoronata (Fuhrmann, 1908)

Dilepidinae Fuhrmann, 1907

Dilepis Weinland, 1834

Dilepis undula (Schrank, 1788)

Anomotaenia Cohn, 1900

Anomotaenia constricta (Molin, 1858)

Anomotaenia verulamii n.sp.

Anomotaenia borealis (Krabbe, 1869)

* Part of a thesis approved by the University of London for the award of the Ph.D. Degree.

Paricterotaenia Fuhrmann, 1932

Paricterotaenia parina (Dujardin, 1845)

Paricterotaenia albani n.sp.

Paricterotaenia mariae n.sp.

Paruterininae Fuhrmann, 1907

Anonchotaenia Cohn, 1900

Anonchotaenia globata (von Linstow, 1879)

Hymenolepididae Fuhrmann, 1907

Hymenolepidinae Perrier, 1897 (Ransom, 1909)

Hymenolepis Weinland, 1858

Hymenolepis serpentulus (Rudolphi, 1810)

Hymenolepis stylosa (Rudolphi, 1809)

Hymenolepis amphitricha (Rudolphi, 1819)

Hymenolepis farciminosa (Goeze, 1782)

Hymenolepis fringillarum (Rudolphi, 1809)

Aploparaksis Clerk, 1903

Aploparaksis dujardinii (Krabbe, 1869)

Davaineidae Fuhrmann, 1907

Davaineinae Braun, 1900

Raillietina Fuhrmann, 1920

Raillietina (*Skrjabinia*) *bonini* (Megnin, 1899)

Discussion of some genera in the Dilepididae

The taxonomic position of three genera, namely *Choanotaenia*, *Anomotaenia*, and *Paricterotaenia* is at present so uncertain that it is difficult to say more than that they are in the family Dilepididae. Originally *Choanotaenia* was believed to have a persistent uterus, and was regarded as a single crowned Dilepidine, the double crowned forms of similar morphology being placed in the genus *Anomotaenia* Cohn, 1900. Fuhrmann (1899) established the genus *Monopylidium* for single and double crowned species, similar in morphology to *Choanotaenia* and *Anomotaenia*, but whose uteri when fully gravid,

contain egg capsules. Unfortunately he moved *infundibulum*, type species of *Choanotaenia*, to this new genus and suggested that in its place *galbulae* Gmelin, 1790, be adopted as the type species of *Choanotaenia*. Railliet and Henry (1909) pointed out that this was unacceptable under the International Code of Zoological Nomenclature, and *Monopylidium* therefore fell as a synonym of *Choanotaenia*. But as Clerc (1903), and Fuhrmann (1907, 1908) believed that *infundibulum* and *musculosum*, the type species of the genus *Monopylidium*, should be in the same genus—i.e. *Choanotaenia* Railliet—the *Choanotaenia* of Fuhrmann, containing those forms with a persistent uterus, was left without a name. Railliet and Henry (1909) therefore renamed Fuhrmann's genus *Icterotaenia*. Cohn (1901), and Ransom (1909) doubted that the uterus of *Choanotaenia infundibulum* did in fact break down into egg capsules, and thought that it was possible to recognise *Choanotaenia* and *Monopylidium* as distinct genera. Meggitt (1927) and Southwell (1930) thought that *Anomotaenia* and *Choanotaenia* were closely related, and that *Icterotaenia* was a synonym of *Choanotaenia*. Fuhrmann (1932) considered that the work of Skrjabin and Cohn showed that *galbulae*, types species of *Icterotaenia*, belonged to the genus *Anomotaenia*. He therefore replaced the genus *Icterotaenia* by the genus *Paricterotaenia*, with *porosa* Rudolphi, 1810 as the genotype. Fuhrmann concluded that the genus *Choanotaenia* was in the sub-family *Dipylidiinae* Stiles, 1896, that it had one or two rows of hooks on the rostellum, and that the uterus finally broke down into egg capsules. This put *Choanotaenia* and *Anomotaenia* in different sub-families, *Anomotaenia* and *Paricterotaenia* both being in the sub-family *Dilepidinae* Fuhrmann, 1907. The position then was that *Anomotaenia* had two rows of hooks and a persistent uterus, *Paricterotaenia* had one row of hooks and a persistent uterus, and *Choanotaenia* had one or two rows of hooks, and the uterus broke down into egg capsules. Lopez-Neyra (1951) re-described *porosa*, type species of *Paricterotaenia*, and found it to have egg capsules each containing a single egg. He therefore transferred it to the genus *Choanotaenia*, which then left *Paricterotaenia* without a type species. The 43 species in the genus he suggested should be distributed among other genera in the family. Lopez-Neyra (1952) also re-described *microrhyncha* type species of the genus *Anomotaenia*, and found that it also finally broke down into egg capsules each containing a single egg. He therefore emended the generic definitions of *Choanotaenia* and *Anomotaenia* so that the point of distinction between them was that there was only one row of hooks in *Choanotaenia* and two in *Anomotaenia*. Joyeux and Baer (1955) found that the uterus of *galbulae* finally broke down into egg capsules,

and they transferred it to the genus *Choanotaenia*. They also retain *musculosa* Fuhrmann, 1896 in the genus *Choanotaenia* although Lopez-Neyra (1952) had designated it the type species of the genus *Monopylidium*, which he re-erected with a modified generic definition. This in any case is in violation of the International Rules of Zoological Nomenclature, and his generic name cannot be accepted.

Choanotaenia Railliet, 1896

Synonyms : *Monopylidium* Fuhrmann, 1899 ; *Prochoanotaenia* Meggitt, 1920 ; *Monopylidium* sub-gen. *Macracanthus* Moghe, 1925 ; *Monopylidium* sub-gen. *Megalacanthus* Moghe, 1925 ; *Multitesticulata* Meggitt, 1929 ; *Viscoia* Mola, 1929.

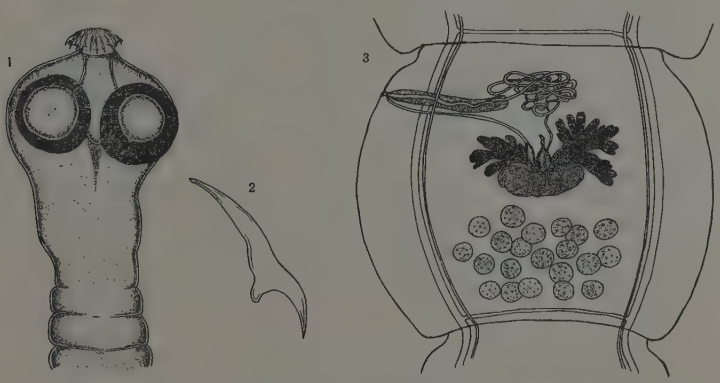
Choanotaenia unicoronata (Fuhrmann, 1908)

Synonyms : *Monopylidium unicoronata* Fuhrmann, 1908 ;
Anomotaenia unicoronata (Fuhrmann, 1908) Clerc, 1911.

Description

Small to medium sized cestodes with a maximum length of 220 mm. and a maximum width of 1·01 mm. The well developed scolex has a diameter of 0·32–0·33 mm., and bears an armed rostellum which when extruded has a diameter of 0·1–0·11 mm. The rostellum bears 20 hooks arranged in a double row, and varying in length between 42 and 46μ. There are also four unarmed suckers 0·12–0·125 mm. in diameter. There is a short neck about 0·15 mm. long, merging into a very short immature region of from 4–12 segments. There are two layers of longitudinal muscles surrounding the body, both made up of single muscle fibres, the outer layer only being continuous around the lateral margins of the segment. The fibres of both layers are continuous from one segment to the next, the lateral ones being smaller than those in the mid-dorsal and mid-ventral regions. The excretory system consists primarily of a dorsal and a ventral pair of lateral longitudinal vessels lying one above the other. The dorsal vessels are 0·006–0·01 mm. in diameter, and the ventral ones 0·015–0·02 mm. The dorsal vessels atrophy in the gravid segments, and the ventral vessels increase in size. The latter are also joined in the posterior region of each segment by a transverse connecting vessel 0·008–0·01 mm. in diameter. In a mature segment there are 18–22 testes situated behind the ovary and vitelline gland, and confined between the excretory canals. They are 0·017–0·025 mm. in diameter. The vas deferens runs

forwards dorsally, becoming greatly convoluted in front of the receptaculum seminis, and having a diameter of 0·01 mm. The cirrus-sac is long and narrow, 0·14 × 0·024–0·028 mm. The cirrus is unarmed, 0·008 mm. in diameter. The genital pores alternate irregularly, each pore opening laterally in the anterior third of the segment. The vagina opens posterior to the cirrus, and passes inwards parallel with and posterior-dorsal to the cirrus-sac. The diameter of the vagina is 3·3μ and that of the lumen 1·5μ. The ovary is a ventral bilobed organ consisting of a right and left group of follicles situated anteriorly to the vitellaria. The follicles are small, numerous, and arranged in finger like projections, being less well developed on the side on which the genital pore opens. The vitelline gland is a



Choanotaenia unicoronata (Fuhrmann, 1908)

Fig. 1. Scolex. Fig. 2. Hook from rostellum. Fig. 3. Mature segment

compact organ lying in the mid-line 0·09–0·11 mm. wide × 0·06 mm. long × 0·07 mm. deep. In the gravid segments the uterus breaks down leaving single encapsulated eggs 0·036 × 0·04 mm. The embryo is 0·023–0·024 × 0·027–0·028 mm., and the embryonic hooks are 0·012–0·014 mm. long.

Discussion

Monopylidium unicoronata was described by Fuhrmann in 1908 from material collected from blackbirds. Clerc (1911) transferred it to the genus *Anomotaenia*, and Fuhrmann (1932) to the genus

Choanotaenia. Lopez-Neyra (1935) created a new genus for it called *Choanofuhrmannia* on the basis of its having uterine egg capsules with two or three eggs. It was originally described as having a single row of 22 hooks 0·048 mm. in length.

By the kindness of Professor Baer I was able to study the type slide of *unicoronata* (Fuhrmann, 1908) which agrees quite well with my material. The measurements were made with the same microscope at the same time, and their relative difference is therefore constant. Professor Baer (private communication) considers that the type specimen of *unicoronata* (there is only one scolex on the slide), has a double row of hooks, and that the species is, on the basis of that specimen, really an *Anomotaenia* (Fuhrmann's definition, not Lopez-Neyra's). From my new material I have been able to confirm that it is correctly placed in the genus *Choanotaenia*, but I think that Fuhrmann was correct in describing the species as having a single row of hooks on the scolex. As a matter of interest the slide was shown to several people in the Department who were equally divided as to whether the specimen had a single or double row of hooks. If Lopez-Neyra's classification of this family is correct in what genus would this species fall? A generic distinction between *Anomotaenia* and *Choanotaenia* based only on the number of rows of hooks on the rostellum is finally bound to fail, as in some cases it is left to the individual worker to decide in which genus a certain species should fall. Logically then one would end by synonymising the two genera.

Joyeux, Baer, and Martin (1936) described a new species from *Corvus rhipidurus* called *Choanotaenia corvi*. They particularly differentiated it from *C. unicoronata*, but Lopez-Neyra (1952) considers the two species to be synonymous, and suggested that the encapsulation process of *C. unicoronata* was not quite complete. In the description of *C. corvi* the authors point out that the hooks may be in one or two rows, and this point has also been raised by other workers (Stunkard and Milford, 1937) in relation to other species. The only real difference between the two species is the diameter of the cirrus-sac, and the two are synonymous.

TABLE I

Choanotaenia spp. recorded from Passeriform birds.

	Country	No. of hooks	No. of rows of hooks	Size of hooks	No. of testes	Cirrus-sac
C. fieldingi (Maplestone & Southwell, 1923)	Australia	80	2	22	16–21	130 × 45
C. galbulae (Gmelin, 1790)	Europe	22–26	2	28–30	15	130–200 × 40–65
C. musculosa (Fuhrmann, 1896)	Europe	20–22	2	25–29	20–30	180–285 × 50
C. passerina (Fuhrmann, 1907)	Europe	35	2	12–16	14–18	135–140
C. spinasocapite (Joyeux & Baer, 1955)	Europe	20–30	2	37–45	20–28	180–250 × 25–40
C. orioli (Joyeux & Baer, 1955)	Europe	15?	?	17	19–22?	120–135 × 25–30
C. platycephala (Rudolphi, 1810)	Europe	?	?	?	10–15?	180 × 29
C. unicoronata (Fuhrmann, 1908)	Europe	22	1	48	20–24	140 × 28
C. *gondwana* (Inamdar, 1934)	India	12	1	18	19	272 × 36
C. microsoma (Southwell, 1922)	India	16–20	?	35	16–20	?
C. sinensis (Joyeux & Baer, 1935)	Indo China	29	2	69	15–25	200–250 × 25–40
C. taylori (Johnston, 1912)	Australia	?	?	?	20	130 × 40
C. iola ? (Lincicome, 1939)	America	17–20	1	32	13–17	?
C. meliphagidarum (Johnston, 1911)	Australia	?	?	?	20	120–130 × 30

All measurements in microns

Dilepis Weinland, 1834

Dilepis undula (Schrank, 1788) Weinland, 1858

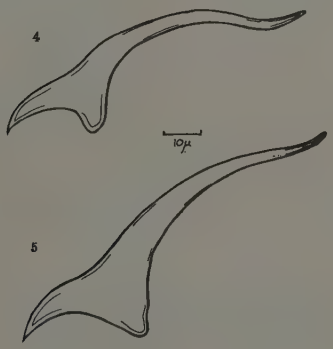
Synonyms : *Taenia angulata* Dujardin, 1845 ; *Dilepis angulata* (Dujardin, 1845) Clerc, 1900 ; *Hymenolepis undulata* Parona, 1899 ; *Dilepis undulata* Volz, 1900 ; *Drepanidotaenia undula* (Schrank, 1788) Rosseter, 1906 ; *Southwellia ransomi* Chapin, 1926.

Description

Medium sized worms varying considerably in size, with a maximum length of 70 mm. and a maximum width of 3·5 mm. The well developed scolex has a diameter of 0·45–0·93 mm., and bears a rostellum armed with 48–64 hooks arranged in a double row. There is no constant size or number of hooks associated with any particular host. The size of the hooks in the first row varies from 0·091–0·116 mm., and those in the second from 0·70–0·088 mm. The neck is 0·55–0·75 mm. long, and merges into a fairly long immature region with evident segmentation. There are two layers of longitudinal muscles surrounding the body, both consisting of a series of muscle fibres arranged in bundles, each bundle being continuous from one segment to the next. Both muscle layers are continuous around the lateral margins of the segment. The excretory system as usual consists of two pairs of lateral excretory canals, the dorsal pair lying slightly inside the ventral pair. The dorsal vessels are 0·008–0·014 mm. in diameter, and the ventral ones 0·028–0·042 mm. The transverse vessel between the ventral pair in each segment is 0·01–0·02 mm. in diameter.

The genital pores are unilateral, opening on the right side of the strobila, and are situated marginally in the anterior half of each segment. In a mature segment there are 28–36 testes situated behind the vitelline gland and the ovary. They are 0·048–0·063 mm. wide × 0·06–0·07 mm. long. The cirrus-sac is long and narrow, being 0·28–0·42 mm. × 0·032–0·044 mm. in diameter. The cirrus is armed with tiny spines and has a diameter of 0·012–0·014 mm. The vagina passes inwards parallel with and either antero-dorsal or postero-dorsal to the cirrus-sac. The former is the more usual position, with the vagina opening into the genital atrium in front of the cirrus, but in some material collected from blackbirds it was noted that the vagina was posterior to the cirrus-sac, or dorsal to it. In sections of this material the vagina was seen to open into the genital atrium immediately above the cirrus, and it is thought

that the relative position of the cirrus-sac and the vagina depended upon the degree of flattening of the specimens. The diameter of the vagina is 0·012 mm. The ovary is made up of two scattered groups of follicles lying anterior and ventral to the vitelline gland. The follicles are round, 0·028–0·04 mm. in diameter, and vary in number from 7–12 in the right group, and from 12–24 in the left group. The vitelline gland is a compact slightly lobed organ situated in the mid-line and in the centre of each segment. It is 0·04–0·07 mm. long × 0·097–0·17 mm. broad. Mehlis' gland lies dorsal to the other female organs, and is 0·08 × 0·03 mm. broad. The uterus is sac like and extends beyond the lateral excretory vessels when it becomes distended with eggs. The embryos are 0·036–0·04 mm. in diameter, and are surrounded by an envelope 0·004–0·048 mm. wide × 0·048–0·056 mm. long. The embryonic hooks are 0·018–0·02 mm. long.



Dilepis undula (Schrank, 1788)

Figs. 4 and 5. Hooks from the rostellum.

Discussion

Dilepis undula was originally described under the name *Taenia undula* by Schrank in 1788 from material collected from Corvid birds. Rudolphi (1810) renamed it *T. undulata*, which Weinland (1858) designated the type species of his new genus *Dilepis*. Fuhrmann (1908) changed the name to *D. undula* in accordance with the Rules for Zoological Nomenclature. *Dilepis undula* has a very wide distribution among Passeriform birds, and Ransom (1902) gave a list of 22 bird species from which it has been reported. As a result of the present survey this figure is now increased to 26.

Anomotaenia Cohn, 1900

Anomotaenia constricta (Molin, 1858) Cohn, 1900

Synonyms : *Taenia coronina* Krabbe, 1869 ; *T. affinis* Krabbe, 1869 ; *T. puncta* von Linstow, 1872 ; *Anomotaenia puncta* Cohn, 1901 ; *Choanotaenia constricta* (Molin, 1858), Clerc, 1903.

Description

Small to medium sized worms, with a maximum length of 105 mm., and a maximum width of 2·6 mm. The well developed scolex has a diameter of 0·04–0·05 mm., and bears a rostellum armed with a double row of hooks. The number of hooks varies between 18–22, but is usually 20. A comparison of material from different hosts showed a slight variation in their size according to the host.

Host	*Length of hooks, first row*	*Length of hooks, second row*
Rook	50–56	45–50
Jackdaw	35–43	31–38
Songthrush	45–52	42–45
Mistlethrush	50–54	44–46
Starling	49–51	42–45
Blackbird	52–56	46–48

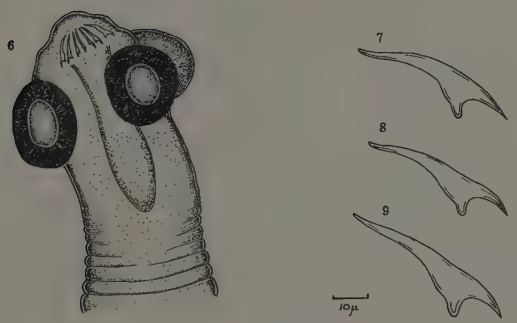
All measurements in microns.

This variation in hook size was also associated with a variation in the size of the cirrus-sac, but there is insufficient evidence at present to consider them as separate strains of this cestode. The diameter of the suckers is 0·14–0·15 mm. There is a short neck, 0·08–0·15 mm. in length which merges into a fairly long immature region with evident segmentation. There are three layers of longitudinal muscles surrounding the body, the outer and middle layers being continuous around the lateral margins of the body. The excretory system follows the usual pattern. The dorsal vessel is 0·008–0·012 mm. in diameter, the ventral 0·025–0·045 mm., and the transverse 0·03–0·035 mm. in diameter. The genital pores alternate irregularly, and are situated in the anterior quarter of each segment, the vagina opening ventral and slightly posterior to the cirrus. In a mature segment there are 49–56 testes, oval in shape,

and varying in size from 0·047–0·084 mm. wide × 0·028–0·058 mm. long depending upon the host. The cirrus-sac varies in size according to the host.

Host	*Size of cirrus-sac*
Rook	80–120 × 42–56
Jackdaw	70– 90 × 36–50
Starling	110–125 × 28–36
Blackbird	130–140 × 23–25

All measurements in microns.



Anomotaenia constricta (Molin, 1858)

Fig. 6. Scolex.
The hooks on the rostellum vary in shape and size depending on the host.

Fig. 7. From a Song Thrush. Fig. 8. From a Jackdaw. Fig. 9. From a Rook

The vagina is up to 0·021 mm. in diameter in rooks, 0·013–0·018 mm. in jackdaws, and slightly smaller still in starlings and blackbirds. The ovary is a paired organ consisting of a right and left group of tightly packed follicles, situated anteriorly to the vitelline gland and to the testes. The follicles are more numerous on the aporal side of the segment. Mehlis' gland lies dorsal to the rest of the female gentialia, and overlies the anterior border of the vitelline gland. The uterus is persistent in the gravid segments. The embryos are 0·042 × 0·035 mm. in diameter, and are each surrounded by an egg membrance 0·052 × 0·044 mm. wide. The embryonic hooks are 0·015 mm. long.

Discussion

Under Fuhrmann's classification of the family Dilepididae this species falls in the genus *Anomotaenia* because of its persistent uterus, double row of hooks, and irregularly alternating genital pores. However Lopez-Neyra (1951) described *microrhyncha*, the type species of the genus *Anomotaenia*, as having a uterus which finally broke down into egg capsules. As a result of his work Lopez-Neyra proposed new generic definitions for the genera *Anomotaenia* and *Choanotaenia*, and completely did away with the genus *Paricterotaenia*. He thought that all the species in the genus *Anomotaenia* (Fuhrmann's definition—not Lopez-Neyra's) would on re-examination be found to have egg capsules. I am unable to confirm this view, and have found three species in which the uterus does not break down into egg capsules, and I therefore reject, at least for the present, Lopez-Neyra's emended classification for this group of genera. For if one accepted Lopez-Neyra's scheme one would have to name two new genera to receive those species with, respectively, one or two rows of hooks on the rostellum, and a persistent uterus, and thus at once the whole situation would become even more complicated than it is at present. While recognizing that the types of the three genera concerned have all now been described as having egg capsules I feel that one should refrain from adding to the confusion by creating these new genera, and that nothing should be done to alter Fuhrmann's classification and his generic definitions until far more, if not all, the species in question have been described from fresh material. Lopez-Neyra has unfortunately built up his new system on the basis of species described in the literature, and on some fantastic interpretations of facts and figures. Far too many of the species in this group of genera are based on material that is not gravid, and I myself in describing a new form elsewhere in this paper am unable to say with certainty whether or not the uterus finally breaks down into egg capsules. It is therefore unnecessary to go out and shoot and type hosts of these species in order to try and collect fresh material. It would be found that in many cases the only characters that can be used for a specific identification are the size, number, and shape of the rostellar hooks, since the anatomy in freshly preserved material is very different from old museum specimens, which often have deteriorated during the passage of time. New features are also probably seen that have escaped previous notice, therefore before upsetting established characters a complete new study must be made of the species. For example Baer (1956) in re-describing *Anomotaenia campylacantha* (Krabbe, 1869) noted that the uterus is at first reticulate and later

fills out effacing the network leaving the usual sac-like organ. Also in *Choanotaenia marchali* (Mola, 1907) there appears to be a different type of egg capsule to that of the usual *Choanotaenia*. Therefore I propose to follow Fuhrmann's classification in this paper, although it is obvious that it is far from being completely satisfactory. When considering exactly what is an egg capsule I have found it necessary to mount a gravid segment on a slide, tease it open and cover with a cover slip before examination. The eggs are then more clearly seen. In *Anomotaenia constricta* the eggs are surrounded by a different sort of egg shell to that in *Choanotaenia unicoronata*. Without

Anomotaenia constricta (Molin, 1858)

Fig. 10. Ventral view of the scolex showing the pattern of the excretory canals to the suckers and to the rostellum.

entering into the controversy of exactly what constitutes the egg shell, on the outside of the eggs of *Choanotaenia unicoronata* there is a distinct layer surrounding the egg shell which is quite absent in the eggs of *Anomotaenia constricta*. This I have taken to be the difference between encapsulated eggs, and ones that are not. A comparative table is given of the species recorded from Passeriform birds which are at present placed in the genus *Anomotaenia*.

Anomotaenia constricta was first described by Molin (1858) from material found in the crow. It has quite a wide distribution amongst Passeriformes, Ransom (1909) giving a list of 10 birds from which it has been recorded. The previous English records are from the Rook, Crow, and Song Thrush (Baylis, 1928) and the Blackbird (Baylis, 1939).

Anomotaenia verulamii, n.sp.

Description

Small to medium sized worms with a maximum lenth of 45 mm., and a maximum width of 1·1 mm. The well developed scolex has a diameter of 0·35–0·37 mm., and bears a rostellum armed with 20 hooks arranged in a double row. The hooks of the first row are 0·063–0·065 mm. in length and those of the second 0·049–0·053 mm. The four suckers have a diameter of 0·147–0·154 mm., and their cavities are covered with tiny scales. There is a short neck, and a fairly long immature region with evident segmentation. The excretory system follows the usual pattern. The dorsal vessel is 0·012 mm. in diameter, the ventral 0·032 mm., and the transverse connecting vessel 0·014 mm. The vessels increase in size as the segments become gravid. The genital pores alternate irregularly and open marginally in the anterior third of each segment, the vagina opening posterior to the cirrus. In a mature segment there are 20–24 testes situated behind the ovary and vitelline gland. They have a diameter of from 0·04–0·058 mm. The cirrus-sac, 0·24 mm. × 0·048 mm. is long and narrow. The vagina passes inwards parallel with the cirrus-sac, and postero-dorsal to it, expanding into a large receptaculum seminis. The ovary consists of a right and left group of small follicles closely packed together, which fill the anterior part of the segment when fully developed. The vitelline gland is a slightly lobed organ, ·060–·065 mm. in diameter, lying in the midline. The uterus is the last of the female organs to appear, and is persistent in the gravid segments. The embryos are ·020–·028 mm. × ·036–·040 mm. and are surrounded by an outer envelope 0·06 mm. in diameter. The embryonic hooks are 0·011–0·012 mm. long.

Host : *Turdus ericetorum ericetorum* Turton

Location : Intestine.

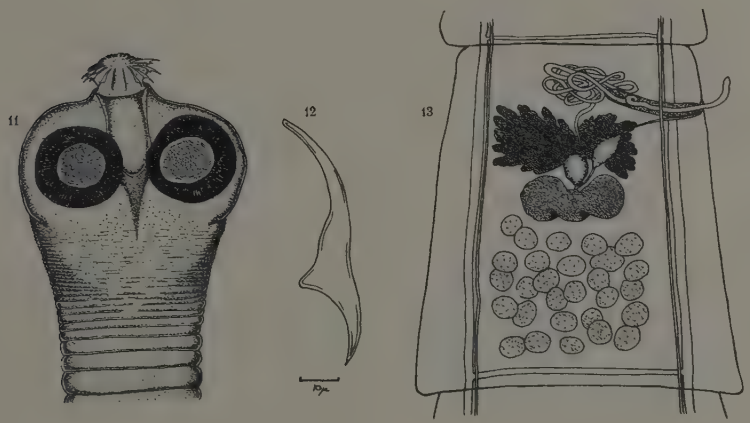
Locality : Hertfordshire.

Type to be deposited in the collection of the London School of Hygiene and Tropical Medicine.

Discussion

This new form falls in the genus *Anomotaenia* because of the double row of hooks on the rostellum, irregularly alternating genital

atria, and persistent uterus. It may be distinguished from other species in the genus by reference to the table of species recorded from Passeriform birds. During this survey only two other species in this genus were found, i.e. *A. constricta*, and *A. borealis*. *Anomotaenia verulamii* may be distinguished from both by the variations in the size of the hooks on the rostellum, the number of testes, and the size of the cirrus-sac.



Anomotaenia verulamii n.sp.

Fig. 11. Scolex. Fig. 12. Hook from the rostellum. Fig. 13. Mature segment.

Anomotaenia borealis (Krabbe, 1869)

Synonyms : *Taenia borealis* Krabbe, 1869 ;

Choanotaenia borealis (Krabbe, 1869) Clerc, 1906.

Description

Small cestodes with a maximum length of 30 mm. and a maximum width of 0·6 mm. The scolex is a well developed, rounded structure 0·35 mm. in diameter. The rostellum bears a double row of 20 hooks. Those in the first row are 0·035–0·038 mm. long and those in the second 0·037–0·042 mm. long. The diameter of the suckers is 0·12–0·13 mm. The short neck merges into the immature

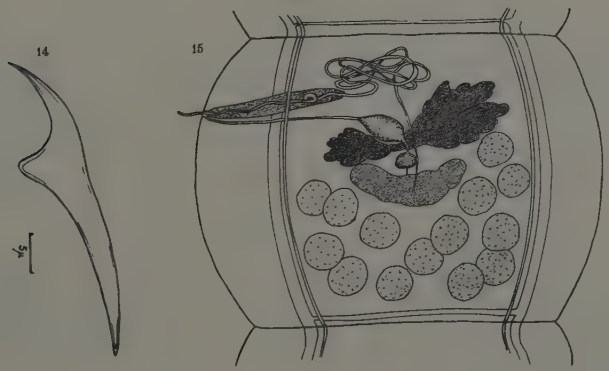
TABLE II

Anomotaenia spp. recorded from Passeriform birds

	Locality	*No. of hooks*	*Size of hooks*	*No. of testes*	*Cirrus-sac*
A. borealis (Krabbe, 1869)	Europe	18–22	37–38	12	170
A. caledonica (Fuhrmann, 1918)	E. Indies	24	23–27	25	100–140
A. constricta (Molin, 1858)	Europe	16–24	See text	50	See text
A. heterocoronata (Fuhrmann, 1918)	E. Indies	26	21–22	50	200–240 × 28
A. hirudina (Fuhrmann, 1907)	?	54–60	19	?	100
A. isacantha (Fuhrmann, 1908)	Brazil	24	75	20–25	?
A. murudensis (Baylis, 1926)	India	20–22	50–55	35–45	150– × 50
A. ovolaciniata (Linstow, 1877)	Europe	38–40	15–18	?	?
A. passerum (Joyeux & Timon-David, 1934)	Europe	22	28–31	15	140–150 × 25
A. penicillata (Fuhrmann, 1908)	Brazil	?	19	25	120
A. praecox (Krabbe, 1882)	Europe	34–40	10–12	13–15	150 × 30
A. quadrata (Rudolphi, 1819)	Europe	Description incomplete			
A. rustica (Neslobinsky, 1911)	Russia	42	49–50	100	380–480 × 100
A. trigonocephala (Krabbe, 1869)	Europe	20	31–34	?	?
A. tarnograskii (Dinnick, 1927)	Russia	20	30–34	32–34	190–225 × 27–36
A. undulatoides (Fuhrmann, 1908)	N. America	44–46	63–75	50	240
A. verulamii n.sp.	Europe	20	49–53	24–28	240 × 48

All measurements in microns

region of the strobila. The excretory system follows the usual pattern. The dorsal vessel is 0·012 mm. in diameter and the ventral 0·04 mm. The genital pores alternate irregularly and open in the anterior third of each segment. In a mature segment there are 12–16 testes, with a diameter of 0·075–0·080 mm. The cirrus-sac 0·16–0·18 × 0·024–0·028 mm. is long and narrow. The vagina opens into the genital atrium posteriorly to the cirrus, and passes inwards parallel with the cirrus-sac. The ovary is a ventral organ consisting of a right and left group of tightly packed follicles. The vitelline gland is a compact organ 0·15 mm. × 0·11 mm. long lying posterior to the ovary. The uterus is persistent in the gravid segments, and becomes greatly distended by the large number of eggs. These embryos are 0·028–0·032 mm. in diameter, and are surrounded by an egg membrane 0·05 mm. in diameter. The embryonic hooks are 0·014 mm. long.



Anomotaenia borealis (Krabbe, 1869)

Fig. 14. Hook from the rostellum. Fig. 15. Mature segment.

Discussion

This cestode was first described by Krabbe in 1869 from material found in *Emberizia nivalis*, the Snow Bunting, in Greenland. Clerc in 1906 re-described it and transferred it to the genus *Choanotaenia*. He was under the impression that Krabbe had been dealing with two species, but Baer (1956) has shown that this was not so, and the variations in the shape of the hooks as figured by Krabbe was due to the different angles at which they were drawn. There are

certain differences between Krabbe's material as re-described by Baer, and Clerc's description. As will be seen from the following table the material I have described from the Song Thrush agrees with Clerc's figures more than with Krabbe's and Baer's, and also the shape of the hooks appears very similar to that given by Clerc.

	Krabbe, 1869	*Clerc*, 1906	*Mettrick* (present paper)
Size	20 × 0·8 mm.	30 × 0·6 mm.	30 × 0·6 mm.
Nos. of hooks	18	20–22	20
Size of hooks (1st row)	23	34–37	35–38
Size of hooks (2nd row)	30		37–42
Nos. of testes	16–20	Circ. 12	12–16
Cirrus pouch	136–204 × 57–45	170 long	160–180 × 24–28
Eggs	37–39 dia.	55 dia.	50 dia.

All measurements in microns unless otherwise stated.

Baer (1956) suggests that it is possible that the species described by Clerc should be given sub-specific rank, but for the time being I agree with Baer in considering it a variety of *Anomotaenia borealis* Krabbe.

Paricterotaenia Fuhrmann, 1932

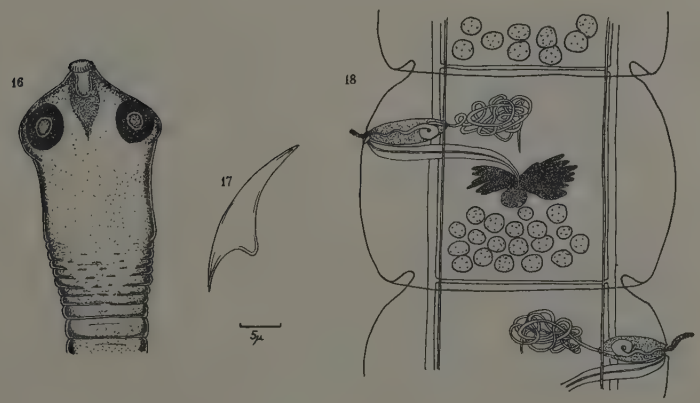
Paricterotaenia parina (Dujardin, 1845) Fuhrmann, 1932

Synonyms: *Taenia parina* Dujardin, 1845; *Drepanidotaenia parina* (Dujardin, 1845) Stossich, 1898; *Choanotaenia parina* (Dujardin, 1845) Clerc, 1906; *Icterotaenia parina* (Dujardin, 1845) Baer, 1925.

Description

Small cestodes with a maximum length of 47 mm. and a maximum width of 1.3 mm. The scolex is small with a diameter of 0·25–0·32 mm., and bears a rostellum armed with 18–20 hooks arranged in a single row. The hooks vary in size between 0·017–0·02 mm. long. The diameter of the four suckers is 0·08–0·09 mm. The short neck merges into the immature region of the strobila. The excretory system follows the usual pattern. The dorsal vessel is 0·008 mm. in diameter, and the ventral 0·025 mm. The genital pores alternate irregularly and are situated marginally in the anterior third of the segment. They open into a shallow atrium.

In a mature segment there are 18–23 testes situated behind the ovary and vitelline gland. They have a diameter of 0·05 mm. The cirrus-sac, 0·15–0·17 mm. long, extends inwards between and just beyond the lateral excretory canals. The cirrus is armed with tiny spines and has a diameter of 0·012 mm. The vagina opens into the genital atrium behind the cirrus, and passes inwards parallel with the cirrus-sac. It has a small lumen, but is surrounded by unusually large gland cells. The ovary is a bilobed organ consisting of a right and left group of closely packed follicles arranged in finger like projections. The vitelline gland is a compact organ situated on the mid-line and in about the middle of the segment. It is slightly lobed, 0·06 mm. × 0·10 mm. wide. Mehlis' gland lies just in front of the vitelline gland, and has a diameter of 0·04–0·05 mm. The uterus is sac-like, and full of eggs. The embryos are 0·03–0·035 mm. in diameter and are surrounded by an envelope 0·045–0·055 mm. in diameter. The embryonic hooks are 0·016 mm. long.



Paricterotaenia parina (Dujardin, 1845)

Fig. 16. Scolex. Fig. 17. Hook from the rostellum. Fig. 18. Mature segment.

Discussion

Fuhrmann (1932) replaced the genus *Icterotaenia* by the genus *Paricterotaenia* with *porosa* Rudolphi, 1810 as the genotype. The generic definition of *Paricterotaenia* differed from that of *Anomotaenia* by the former having a single crown of hooks on the rostellum, and

the latter having a double crown. Lopez-Neyra (1951) re-described *porosa* Rudolphi, 1810 and found that the uterus was not persistent in the gravid segments, but finally broke down into egg capsules. He therefore transferred *porosa* to the genus *Choanotaenia*, which left *Paricterotaenia* without a geno-type. This invalidated the genus, and Lopez-Neyra suggested that the remaining 43 species in the genus should be placed either in related genera, or in one or more new genera as required.

I have previously mentioned Lopez-Neyra's work, including his invalidation of this genus, and have discussed the reasons why both his classification and his suggestion that the species in the genus *Paricterotaenia* be placed in other existing genera in the same family, are unacceptable because of our present lack of reliable descriptions of the species concerned.

A comparative table is given of the species in the genus *Paricterotaenia* recorded from Passeriform birds. *Paricterotaenia parina* was originally described from material found in *Aegithalos caudatus* (Long-tailed Tit), and has a wide distribution amongst birds in the families *Paridae* and *Fringillidae*.

Paricterotaenia albani n.sp.

Description

Small cestodes with a maximum length of 59 mm., and a maximum width of 1·3 mm. The scolex has a diameter of 0·32–0·35 mm., and bears a rostellum armed with 26 hooks 0·021–0·022 mm. long, arranged in a single row. The rostellum is a rounded, conical shaped structure and has a diameter of 0·075 mm. The diameter of the four unarmed suckers is 0·135 mm. The short neck, 0·3 mm., merges into the immature region of the strobila. The excretory system follows the usual pattern. The dorsal vessel is 0·006–0·008 mm. in diameter, and the ventral 0·024 mm., while the transverse connecting vessel is 0·01 mm. in diameter. The genital pores alternate irregularly, although the majority open on the right of the strobila. In a mature segment there are 20–22 testes with a diameter of 0·03–0·05 mm. They tend to extend forwards in the lateral fields so that they are level with the vitelline gland. The thin-walled cirrus-sac 0·25–0·28 mm. $\times$ 0·03 mm. is long and narrow. The vagina passes inwards at right angles to the axis of the segment, whereas the cirrus-sac tends to run forward. The ovary is a ventral bilobed organ consisting

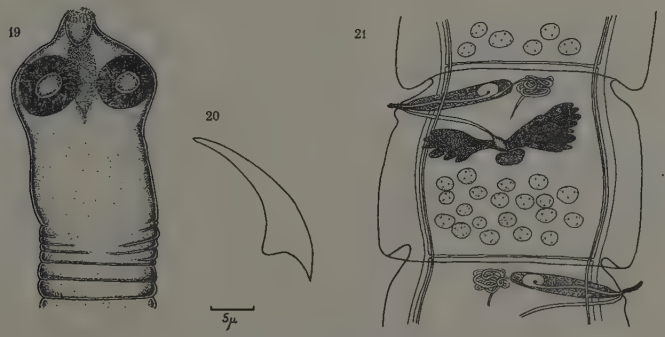
of tightly packed follicles in finger like projections. The right and left group of follicles are joined by a distinct ovarian bridge. The compact vitelline gland, slightly crescentic in shape, is 0·15–0·18 mm. wide × 0·03 mm. deep, and lies just behind and ventral to Mehlis' gland. The uterus is sac-like and persistent in the gravid segments. The embryos are 0·02 × 0·016 mm., and are surrounded by an envelope 0·032–0·035 mm. in diameter. The embryonic hooks are 0.01 mm. long.

Host : *Sturnus vulgaris vulgaris* Lin.

Location : Intestine.

Locality : Hertfordshire.

Type specimen to be deposited in the collection of the London School of Hygiene and Tropical Medicine.



Paricterotaenia albani, n.sp.

Fig. 19. Scolex. Fig. 20. Hook from the rostellum. Fig. 21. Mature segment

Discussion

This species falls in the genus *Paricterotaenia* because of its single row of hooks on the rostellum, irregularly alternating genital pores, and persistent uterus. Of the other species in this genus (see Table III) it most closely resembles *P. parina*, also described in this paper, and which was found in the same host. It may be distinguished from *P. parina* by the following points : The maximum number of hooks found in *P. parina* was 20, and their maximum length 0·02 mm. These figures were found to be consistent in material

examined from four different hosts, as well as agreeing with descriptions of earlier workers. As opposed to this *P. albani* has 26 hooks, with a maximum length of 0·022 mm. The cirrus-sac of *P. parina* is up to 0·17 mm. long, and only extends inwards just beyond the lateral excretory canals. The ratio of the length of the cirrus-sac to the total width of the segment is 1 : 5–6. In *P. albani* the cirrus-sac is much longer, having a maximum length of 0·28 mm., and the

TABLE III

Paricterotaenia spp. recorded from Passeriform birds

	Locality	*No. of hooks*	*Size of hooks*	*No. of testes*	*Cirrus-sac*
P. barbara (Meggitt, 1926)	Burma	23	17	24–26	———
P. chlamyderae (Krefft, 1871)	Europe	Description incomplete			
P. inominata (Meggitt, 1926)	Burma	26	15–17	18–20	200–240
P. magnicirrosa (Meggitt, 1926)	Burma	22–24	18–19	27	250–350
P. parina (Dujardin, 1845)	Europe	17–20	15–20	20	170
P. parvirostris (Krabbe, 1869)	Europe	20–30	11–14	18–20	150–200
P. passerellae (Cooper, 1921)	Alaska	?	?	20–25	250–270 × 56
P. mariae n.sp.	Europe	10	52–53	12–14	180–220 × 24–26
P. albani n.sp.	Europe	26	21–22	20	250–280 × 30

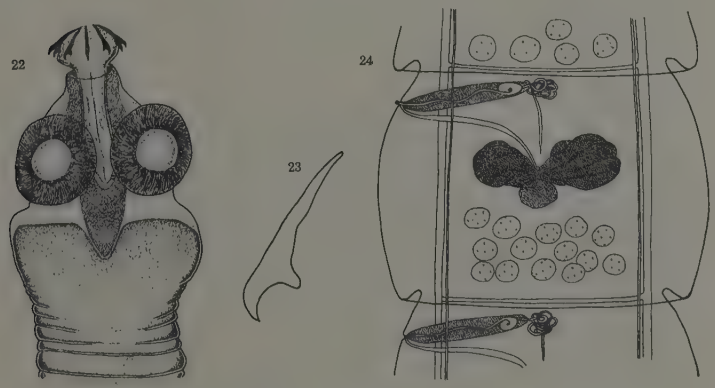
All measurements in microns

ratio of the length of the cirrus-sac to the total width of the segment is 1 : 2–3. The vagina of *P. parina* is very well developed and is very conspicuous, whereas in *P. albani* it is neither so well developed nor so conspicuous. In *P. albani* the two lobes of the ovary are separated by a distinct ovarian bridge, which is completely absent in *P. parina*.

Paricterotaenia mariae n.sp.

Description

Small to medium sized worms with a maximum length of 65 mm., and a maximum width of 0·83 mm. The well developed scolex is coneshaped with a diameter of 0·2 mm. The rostellum is armed with a single row of 10 hooks which are 0·048–0·05 mm. long. The four suckers are 0·1–0·11 mm. in diameter, have poorly developed musculature, and extend beyond the margins of the scolex. The neck is short and thicker than the scolex (possibly due to fixation), and merges into a very short immature region. The excretory



Paricterotaenia mariae, n.sp.

Fig. 22. Scolex. Fig. 23. Hook from the rostellum. Fig. 24. Mature segment.

system follows the usual pattern. The dorsal vessel is 0·006 mm. in diameter, and the ventral 0·016 mm. The genital pores alternate irregularly, and open marginally in the anterior quarter of each segment. There is a shallow genital atrium. In a mature segment there are 12–14 testes, 0·024–0·027 mm. in diameter. The cirrus-sac 0·18–0·22 mm. × 0·024–0·026 mm. is long and narrow. The cirrus, 0·016 mm. in diameter is armed with tiny spines. The vagina passes inwards slightly towards the posterior part of the segment. The ovary is ventral in position, and consists of two lobes of tightly packed follicles, the aporal lobe always being the larger. The vitelline gland lies in the mid-line just in the posterior half of the segment.

It is 0·04–0·045 mm. in diameter. The uterus is sac-like, and persistent in the gravid segments. The embryos are 0·024 × 0·02 mm., and are surrounded by an envelope 0·03–0·035 mm. in diameter. The embryonic hooks are 0·012 mm. long.

Host : *Erithacus rubecula melophilus*

Location : Intestine.

Locality : Hertfordshire.

Type to be deposited in the collection of the London School of Hygiene and Tropical Medicine.

Discussion

This species is readily distinguished from the other species in the genus *Paricterotaenia* by the number and size of the hooks on the rostellum. As the fully gravid segments of these specimens had been lost it is just possible that in the fully gravid segments the uterus may finally break down leaving egg capsules, in which case this species should be placed in the genus *Choanotaenia*. In this genus also it is at once identified by means of the rostellar hooks. However until further material is available for study I propose to place this species in the genus *Paricterotaenia*.

Anonchotaenia Cohn, 1900

Synonym : *Amerina* Fuhrmann, 1901

Anonchotaenia globata (von Linstow, 1879)

Synonyms : *Taenia globata* von Linstow, 1879 ; *T. rudolphiana* von Linstow, 1879 ; *T. breviceps* von Linstow, 1879 ; *T. laxiae recurvirostrae* Blumenbach, 1779 ; *T. clavata* Marchi, 1869 ; *Anonchotaenia clava* Cohn, 1900 ; *Anurina inermis* Fuhrmann, 1901 ; *Amerina inermis inermis* Clerc, 1902 ; *Amerina alaudae* Cerutti, 1901.

Description

Small to medium sized cestodes with a maximum length of 66 mm., and a maximum width of 1·0 mm. The well developed scolex is 0·53–0·62 mm. in diameter. There is no rostellum and the

scolex is completely unarmed. The four suckers have a diameter of 0·2–0·24 mm. The neck is rather long being 1·2–1·5 mm × 0·25–0·26 mm. wide. The excretory system follows the usual pattern. The dorsal vessel is 0·006–0·008 mm. in diameter, and the ventral 0·012–0·014 mm. The genital pores alternate irregularly, and open marginally by a deep atrium in the middle of each segment. In a mature segment there are 5 testes arranged in a transverse row. They are 0·028–0·035 mm. in diameter, and lie rather dorsally in the anterior part of the segment. The vas deferens is tortuous, but does not form a mass of coils, and lies ventral to the testes. The cirrus-sac is club shaped 0·07–0·08 mm. long × 0·024–0·03 mm. wide. The vagina passes inwards parallel with the cirrus-sac. The ovary is a compact round organ 0·05–0·058 mm. in diameter, ventral in position in the posterior part of the segment. It lies between the vitelline gland, which is in the mid-line, and the genital atrium. The uterus is at first a sac-like organ which develops in front of and dorsal to the ovary. The eggs when in the uterus are 0·013–0·017 mm. in diameter. There are no embryonic hooks. Woodland (1929) described the development of these eggs in some detail. He stated that the embryo first elongates and grows until it is about 0·11 mm. long. It then coils itself in the mid-region, the investing nucleated membrane becomes detached from the coils and forms a loose sac round them. Finally the embryo is tightly coiled in this sac and measures 0·026 × 0·018 mm. The embryos now pass into the paruterine organ which meanwhile has been developing at the anterior end of the uterus. The two organs, i.e. uterus and paruterine organ together form a rather ovoid structure lying in the middle of the segment, and slightly diagonal in position when the segments are well relaxed. The embryos in the paruterine organ are few, and are spindle shaped due to the two surrounding membranes which are prolonged into slender poles. The outer membrane is 0·03–0·035 mm. long.

Discussion

This species is interesting because of the nematode-like embryos, and the complete lack of embryonic hooks. Its life-cycle, if known, would perhaps explain these characters. *Anonchotaenia globata* was originally described from *Parus caeruleus* (Blue Tit), and has a wide host range, Ransom (1909) giving a list of 16 recorded hosts.

Hymenolepis Weinland, 1868.

Synonyms : *Diplacanthus* Weinland, 1858 ; *Lepidotrias* Weinland, 1858 ; *Dicrotaenia* Railliet, 1892 ; *Weinlandia* Mayhew, 1925 ; *Wardium* Mayhew, 1925 ; *Fuhrmanniella* Tseng Shen, 1932.

Hymenolepis serpentulus (Rudolphi, 1810) Weinland, 1858

Synonyms : *Taenia serpentulus* Rudolphi, 1810 ; *Diplacanthus serpentulus* (Rudolphi, 1810), Volz, 1899 ; *Hymenolepis* (*Drepanidotaenia*) *serpentulus* (Rudolphi, 1810), Clerc, 1903 ; *Weinlandi serpentulus* (Rudolphi, 1810) Mayhew, 1925.

Long thin cestode with a maximum length of over 60 mm., and a maximum width of 1·5–2·0 mm. The well developed scolex is 0·29–0·34 mm. in diameter, the rostellum is armed with a single row of 10 hooks, usually 0·023–0·025 mm. in length. They may however vary between 0·018–0·027 mm. in length. The four unarmed suckers are 0·08–0·085 mm. in diameter. The neck is long and narrow being 0·45–0·48 mm. × 0·15–0·16 mm. wide. The excretory system follows the usual pattern. The dorsal vessel is 0·006–0·008 mm. in diameter, and the ventral 0·029 mm. The transverse vessel is 0·01–0·012 mm. in diameter. The genital pores are unilateral and open marginally on the left of the strobila in the anterior third of the segment. Irregularities may occur, especially towards the posterior end of the strobila. The genital ducts pass inwards dorsal to the lateral excretory canals. In a mature segment there are three testes—two are aporal and in tandem, while the third is poral and posterior to the cirrus-sac. They have a diameter of 0·15–0·2 mm. The external vesicula seminalis when fully developed is 0·23–0·29 mm. long × 0·1–0·14 mm. wide, and overlaps the two aporal testes and the receptaculum seminis. The cirrus-sac is 0·18–0·19 mm. × 0·085–0·11 mm. and has a thick and muscular wall. The ovary lies in the middle of the segment ventral to the male organs. The vitelline gland is round and compact, 0·075 mm. in diameter, lying just behind the ovary. The uterus is branched and fills the segment when gravid. The eggs are surrounded by an envelope 0·06–0·07 mm. × 0·044–0·048 mm. The embryo is 0·028–0·036 mm. × 0·036–0·04 mm., and the embryonic hooks 0·02–0·022 mm. long.

Both the external vesicula seminalis and the receptaculum seminis are very large in this species, the former overlying part of the receptaculum seminis. The two organs when well developed occupy, with the cirrus-sac, most of the segment, and give a rather characteristic appearance to the mature region of the strobila, for

all the other organs are either obscured or pushed out of place. The ovary of *Hymenolepis serpentulus* is never well developed as in *H. farciminosa*, *H. fringillarum*, or *H. amphitricha*, and always remains fairly small. Markowski (1933) paid considerable attention to the musculature of this species, counting the number of bundles in each layer of longitudinal muscles, and measuring the size of the individual fibres. It was found that the number of bundles varied considerably—i.e. 25–62 in the outer muscle layer—and of course the size of the fibres depended upon the degree of relaxation of the specimen when fixed. Unfortunately the only certain character for the differentiation of species in this genus is the size and shape of the rostellar hooks. It is therefore impossible to identify with certainty specimens which have lost their scolices.

Hymenolepis stylosa (Rudolphi, 1809)

Synonyms: *Taenia stylosa* Rudolphi, 1809; *Diplacanthus stylosa* (Rudolphi, 1809) Volz, 1899; *Hymenolepis stylosa* (Rudolphi, 1809) Railliet, 1899; *H.* (*Drepanidotaenia*) *stylosa* (Rudolphi, 1809) Clerc, 1903; *Weinlandia stylosa* (Rudolphi, 1809) Mayhew, 1925.

Long elongate cestodes with a maximum length of 100 mm., and a maximum width of 1·8 mm. The scolex is 0·25–0·28 mm. in diameter. The rostellum is armed with a single row of 10 hooks, 0·032–0·038 mm. long. The diameter of the four unarmed suckers is 0·08–0·1 mm. The neck is up to 0·6 mm. long × 0·1 mm. wide. The dorsal excretory vessel is 0·008–0·01 mm. in diameter and the ventral 0·04 × 0·02 mm. The genital pores are unilateral opening on the right of the strobila in the anterior third of each segment. The two aporal testes may be in tandem or slightly oblique to each other. The testes are 0·12–0·15 mm. in diameter. The large external vesicula seminalis when fully developed occupies a considerable part of the segment, overlying the two aporal testes, the receptaculum seminis, and the ovary. The cirrus-sac is 0·22–0·27 mm. × 0·07–0·075 mm. wide and is constricted into two parts. The posterior region is large and contains the internal vesicula seminalis which is 0·1–0·11 mm. × 0·075 mm. wide. The ovary is small, lobed, follicular, and lies in the middle of the segment. The vitelline gland is a compact body lying between the two posterior testes, and is 0·1 mm. × 0·045–0·06 mm. The folds in the wall of the uterus are clearly seen in the early gravid segments. The embryos are 0·04–0·048 mm. × 0·032–0·04 mm., and are surrounded by a thin envelope. The embryonic hooks are 0·018–0·02 mm. long.

The anatomy of this species is very similar to that of *Hymenolepis serpentulus*. The differences between the two species are slight, and it is not possible to tell, from an examination of the strobila alone, which species is which. It was noted that the genital pores of *H. stylosa* open on the right side of the strobila, and that no irregularities occurred in their unilateral placing, whereas in *H. serpentulus* the pores usually open on the left of the strobila and irregularities occurred especially towards the posterior end. Also the lateral excretory vessels are larger and the internal muscle layers are better developed in *H. stylosa* than in *H. serpentulus*.

Hymenolepis amphitricha (Rudolphi, 1819)

Synonyms : *Taenia amphitricha* Rudolphi, 1819 ; *Hymenolepis amphitricha* (Rudolphi, 1819) Railliet, 1899 ; *H.* (*Drepanidotaenia*) *amphitricha* (Rudolphi, 1819) Clerc, 1903 ; *Weinlandia amphitricha* (Rudolphi, 1819) Mayhew, 1925.

Insufficient material was available to make a complete description of this cestode.

Long elongate cestodes with a maximum length of 42 mm. and a maximum width of 1·1 mm. The scolex is 0·31 mm. in diameter. The rostellum is armed with a single row of 10 hooks, 0·02 mm. long. The neck is short, 0·05–0·06 mm. only and is 0·022–0·025 mm. in diameter. The genital pores are unilateral and open marginally in the anterior third of each segment. The arrangement of the genitalia follows the usual hymenolepid pattern. The testes are 0·08–0·085 mm. in diameter. The cirrus-sac is 0·18–0·19 mm. long × 0·035–0·04 mm. wide. The ovary is large, lobed and follicular lying in the middle of the segment. The compact vitelline gland is 0·08–0·087 mm. diameter, and lies between the two posterior testes. In the specimens examined the uterus had not begun to develop.

Clerc (1903) says that the uterus first appears in the posterior part of the segment, but he does not give the size of the eggs, nor are they mentioned in Krabbe's (1869) equally brief description of this cestode. Clerc (1903) also says that the cirrus is probably very long, although he did not see it everted.

Hymenolepis farciminosa (Goeze, 1782)

Synonyms : *Taenia farciminosa* Goeze, 1782 ; *Diplacanthus farciminosa* (Goeze, 1782) ; *Hymenolepis farciminosa* (Goeze, 1782) Railliet, 1899 ; *Weinlandia farciminosa* (Goeze, 1782) Mayhew, 1925.

Long elongate cestodes with a maximum length of 82 mm. and a maximum width of 1·2 mm. The scolex is 0·18–0·25 mm. in diameter. The rostellum is armed with a single row of ten hooks 0·02–0·024 mm. long. The diameter of the four suckers is 0·085–0·09 mm. The neck is 0·3 mm. long and only 0·085 mm. wide. The excretory system follows the usual pattern. The dorsal vessel overlies the ventral which is 0·03 mm. in diameter. The genital pores are unilateral, opening marginally on the left of the strobila in the middle of each segment. The arrangement of the genitalia follows the usual hymenolepid pattern. The testes are 0·09–0·1 mm. in diameter. The cirrus-sac is 0·2 mm. × 0·045 mm., and the internal vesicula is comparatively small. The receptaculum seminis is quite well developed and completely covers the external vesicula seminalis. The large ovary is lobed, follicular and ventral in position, extending beyond the lateral margins of the testes when fully developed. The compact vitelline gland is 0·09 mm. × 0·1 mm. and lies between the two posterior testes. The embryos are 0·048 mm. × 0·03 mm., and are surrounded by an outer envelope 0·06 mm. × 0·065 mm. The embryonic hooks are 0·02 mm. long.

The two aporal testes lie slightly obliquely to each other. The external vesicula seminalis is small and is covered by the receptaculum seminis. The very brief original description of this cestode referred to the cirrus-sac as being 0·12 mm. long, whereas in this material it was much longer, usually being nearly 0·2 mm. in length, and having a uniform diameter. There is no large swelling in the posterior part of the cirrus-sac, and the internal vesicula seminalis is not conspicuous.

Hymenolepis fringillarum (Rudolphi, 1809)

Synonyms : *Taenia fringillarum* Rudolphi, 1809 ; *T. leptodera* von Linstow, 1879 ; *Aploparaksis fringillarum* (Rudolphi, 1809) von Linstow, 1904 ; *Hymenolepis fringillarum* (Rudolphi, 1809) Fuhrmann, 1926.

Insufficient material was available to make a complete study of this cestode.

Long elongate cestodes with a maximum length of 32 mm. and a maximum width 0·8 mm. Joyeux and Baer (1936) give the length as up to 100 mm. The small scolex is 0·28–0·3 mm. in diameter. The rostellum is armed with a single row of 10 hooks 0·026–0·028 mm. long. The four suckers are oval in shape 0·12 mm. × 0·09 mm. The neck is long and narrow 0·65 × 0·15 mm. The genital pores are

unilateral and open marginally on the left of the strobila in the middle of each segment. The arrangement of the genitalia follows the usual hymenolepid pattern. The testes are 0·15–0·17 mm. in diameter. The external vesicula seminalis is large 0·12 × 0·045 mm. and enters the cirrus-sac which is 0·11 × 0·04 mm. The ovary is large and follicular extending beyond the lateral margins of the aporal testes. The compact vitelline gland is 0·11 mm. in diameter, and lies between the two posterior testes. Joyeux and Baer (1936) give the size of the embryo as 0·048 × 0·036 mm. and the surrounding outer envelope as 0·12–0·14 mm. in diameter. The embryonic hooks are 0·02 mm. long.

While it is possible to identify this species by the shape of the hooks on the rostellum, they can possibly be confused with those of *H. stylosa*. However the size of the hooks can also be taken into consideration, for those of *H. stylosa* are 0·032–0·038 mm. in length, while those of *H. fringillarum* are 0·026–0·028. The general anatomy and arrangement of the genitalia are very similar to the usual hymenolepid pattern.

Aploparaksis Clerc, 1903

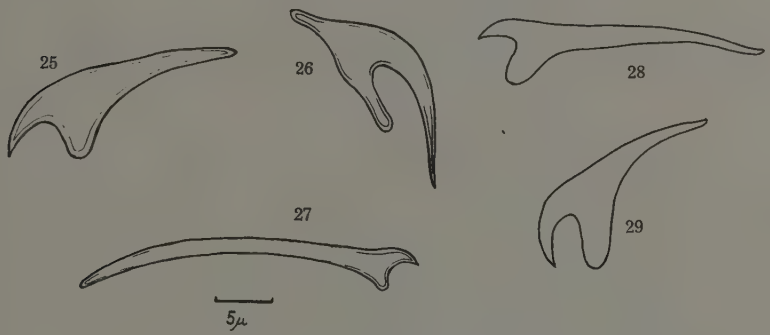
Synonyms : *Monorchis* Clerc, 1902 ; *Haploparaksis* Neslobinsky, 1911 ; *Skorikowia* Linstow, 1905 ; *Haploparaxis* Mayhew, 1925.

Aploparaksis dujardinii (Krabbe, 1869)

Synonyms : *Taenia dujardinii* Krabbe, 1869 ; *Monorchis dujardinii* (Krabbe, 1869) Clerc, 1902 ; *Aploparaksis dujardinii* (Krabbe, 1869), Clerc, 1903 ; *Haploparaxis dujardinii* (Krabbe, 1869), Mayhew, 1925.

Very long elongate cestodes with a maximum length of 105 mm. and a maximum width of 0·9 mm. The scolex is 0·36 mm. in diameter. The rostellum is very bulbous, 0·15 mm. in diameter, and is armed with a single row of 46 hooks 0·016–0·018 mm. long. The four suckers are small and 0·09 mm. in diameter. The genital pores are unilateral and open marginally on the left of the strobila near the middle of the segment. The single aporal testis, 0·07 mm. in diameter lies opposite the genital atrium. The cirrus-sac is up to 0·25 mm. long. The external vesicula seminalis varies in size and lies in front of the testis. The female genitalia are ventral in position underneath the male organs. The vitelline gland lies under the testis. The ovary is slightly lobed and median in position. The uterus first appears in

the posterior ventral region of the segment, and when fully developed extends beyond the lateral excretory canals. The embryos are 0·02–0·025 mm. in diameter, and are surrounded by an envelope 0·035–0·04 mm. in diameter. The embryonic hooks are 0·01 mm. long.



Hooks of some *Hymenolepis* species

Fig. 25. *H. serpentulus* (Rudolphi, 1810). Fig. 26. *H. amphitricha* (Rudolphi, 1819). Fig. 27. *H. stylosa* (Rudolphi, 1809). Fig. 28. *H. fringillarum* (Rudolphi, 1809). Fig. 29. *H. farciminosa* (Goeze, 1782).

Fuhrmann (1895) made a detailed study of this cestode from material collected from Starlings and Song Thrushes. He states that the dorsal excretory vessel is 0·027 mm. in diameter, and overlies the ventral which is 0·033 mm. in diameter. Both vessels lie ventral to the genital ducts. The cirrus is slender and armed at its proximal end with small spines. Fuhrmann gave the size of the eggs as 0·011 mm. in diameter, but, as Yamaguti (1935) pointed out, this is probably a mistake, and is identical with the figure given by Krabbe (1869), in his original description, for the embryonic hooks. Krabbe (1869) described this cestode from material collected from a Song Thrush. In this country it has been recorded from the Blackbird, Song Thrush, and possibly the Starling (Baylis, 1928). The latter as a host in this country is now confirmed.

Raillietina Fuhrmann, 1920

Synonyms : *Brumptiella* Lopez-Neyra, 1929 ; *Idiogenoides* Lopez-Neyra, 1929 ; *Kotlania* Lopez-Neyra, 1929 ; *Meggittia* Lopez-Neyra, 1929.

The four sub-genera in this genus are split up on the basis of the number of eggs in the parenchymatous egg capsules, and the

alternation of the genital pores. The sub-genus *Skrjabinia* has irregularly alternating genital pores, and one egg per egg capsule.

Raillietina (*Skrjabinia*) Fuhrmann, 1920

Synonyms : *Brumptiella* Lopez-Neyra, 1929, *ex-parte* ; *Meggittia* Lopez-Neyra, 1929 *ex-parte.*

Raillietina (*Skrjabinia*) *bonini* (Megnin, 1899)

Synonym : *Taenia bonini* Megnin, 1899

Description

Very long elongate cestodes with a maximum length of 155 mm., and a maximum width of 1·4 mm. The scolex is 0·17–0·18 mm. in diameter. The small rostellum is armed with a double row of 120 hooks 0·01–0·012 mm. long. The suckers are 0·048–0·05 mm. in diameter, and are heavily armed with a mass of very small hooks 0·005–0·008 mm. long. The excretory system follows the usual pattern. The dorsal vessel is 0·014–0·018 mm. in diameter, and the ventral increases in size from 0·03 mm. diameter to cover 0·07 mm. in the gravid region. The genital pores alternate irregularly and open marginally in the anterior third of the segment. In a mature segment there are 26–30 testes, extending laterally between the excretory canals, and 0·07–0·09 mm. in diameter. The thick-walled cirrus-sac is very well developed and runs forward to the anterior border of the segment. It is up to 0·68 mm. long $\times$ 0·3 mm. wide. The cirrus is 0·016 mm. in diameter, and is armed with tiny spines. The ovary is a paired organ consisting of two lobes of tightly packed follicles extending between the lateral excretory vessels. The vitelline gland is 0·08–0·09 mm. in diameter, and lies just behind the ovary. The gravid segments contain a mass of parenchymatous egg capsules each contained a single egg. The embryos are 0·036 mm. in diameter, and are surrounded by an envelope 0·044–0·046 mm. in diameter. The embryonic hooks are 0·016 mm. long.

Discussion

In 1899 Megnin described this cestode from the Wood Pigeon. It has not been recorded from any other host, and was recorded from this country by Baylis (1939).

List of cestodes and their hosts recorded during this survey.

Choanotaenia unicoronata	**Turdus ericetorum* (Song Thrush)
	**T. viscivorus* (Missel Thrush)
Dilepis undula	*Turdus ericetorum*
	T. viscivorus
	T. merula (Blackbird)
	T. pilaris (Fieldfare)
	Corvus frugilegus (Rook)
	C. monedula (Jackdaw)
	†*C. corone* (Carrion Crow)
	Sturnus vulgaris (Starling)
	†*Garrulus glandarius* (Jay)
	†*Pica pica* (Magpie)
	**Parus ater* (Coal Tit)
	**P. caeruleus* (Blue Tit)
	**Prunella modularis* (Hedge Sparrow)
	**Passer domesticus* (House Sparrow)
Paranomotaenia constricta	*Turdus ericetorum*
	**T. viscivorus*
	T. merula
	T. pilaris
	Corvus frugilegus
	†*C. monedula*
	†*C. corone*
	**Sturnus vulgaris*
	**Garrulus glandarius*
Paranomotaenia verulamii n.sp.	**Turdus viscivorus*
Paranomotaenia borealis	**Turdus ericetorum*
Paricterotaenia parina	†*Sturnus vulgaris*
	**Parus ater*
	†*Prunella modularis*
	†*Passer domesticus*
	†*Parus caeruleus*
	**P. ater*
Paricterotaenia albani n.sp.	**Sturnus vulgaris*

Paricterotaenia mariae n.sp.	**Erithacus rubecula* (Robin)
Anonchotaenia globata	†*Fringilla coelebs* (Chaffinch)
Hymenolepis serpentulus	*Turdus ericetorum* †*T. viscivorus* *T. merula* †*T. pilaris* †*Corvus frugilegus* *C. monedula* *C. corone* **Sturnus vulgaris* †*Garrulus glandarius* †*Pica pica*
Hymenolepis stylosa	*Garrulus glandarius* **Corvus frugilegus* †*C. corone* †*C. monedula* †*Pica pica*
Hymenolepis amphitricha	†*Capella gallinago* (Snipe)
Hymenolepis farciminosa	*Sturnus vulgaris* †*Pica pica*
Hymenolepis fringillarum	*Sturnus vulgaris* †*Prunella modularis* †*Fringilla coelebs* **Parus ater*
Aploparaksis dujardinii	†*Sturnus vulgaris*
Raillietina (*Skrjabinia*) *bonini*	*Columba palumbus* (Wood Pigeon)

* denotes a new host record
† denotes a new record for this country

SUMMARY

1. Descriptions are given of 16 species of cestode found in Hertfordshire birds.

2. The taxonomic position of the genera *Choanotaenia* Railliet, 1896; *Anomotaenia* Cohn, 1900; and *Paricterotaenia* Fuhrmann, 1932, is discussed in detail.

3. A new species *Anomotaenia verulamii*, n.sp., from the Song Thrush (*Turdus ericetorum*) is described.

4. A new species *Paricterotaenia albani*, n.sp., from the Starling (*Sturnus vulgaris*) is described.

5. A new species *Paricterotaenia mariae*, n.sp., from the Robin (*Erithacus rubecula*) is described.

6. A total of 18 new host records and 23 new records for this country are reported.

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Observations on Nematode Infections of Goats and Sheep in West Africa

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The present paper is intended as a preliminary contribution relating to worm infections of domestic animals in West Africa. It embodies an account of the results appertaining to the worm-burden of goats and sheep in the southern region of Ghana based on fortnightly counts of eggs of nematodes present in the faeces over a period of three years, 1954—1956, inclusive. Some observations on the incidence of tapeworms of the genus *Moniezia* are also included. No eggs of any helminths were seen other than those of *Moniezia* and various species of nematodes, except for an occasional egg of *Schistosoma* sp., probably *S. bovis*, in two sheep of the local breed known as the West African Dwarf Forest Sheep.

Methods and Centres of Study

Samples of faeces taken from the rectum of each animal were transported to the laboratory in numbered containers for examination. The egg-counting technique used was that devised by Gordon and Whitlock (1939) with certain modifications described by Morgan, Parnell and Rayski (1950). From each sample, two grammes of faeces were weighed and rubbed through a small sieve resting in an evaporating dish, 4 in. in diameter, containing 30 cc. of saturated salt solution. A further 30 cc. of the salt solution was used to wash the remains of the faecal sample left on the sieve. The entire contents of the evaporating dish, faeces and salt solution, were then thoroughly stirred, and simultaneously a sufficient quantity of the mixture was drawn into a pipette to fill four cells of the McMaster Egg-counting Slide, two cells on each of two slides. A count was made of all the nematode eggs floating on the surface of the liquid in each cell, that is, the number present in 0·15 cc. The total in four cells multiplied by 50 gave the number of eggs per gramme of faeces.

The goats and sheep included in these studies were kept under field conditions, all being allowed to graze freely over fairly extensive tracts of self-established swards largely composed of indigenous species of plants. Flocks at four separate centres were involved: (a) Trypanosomiasis Research Station, Achimota; (b) Government Agricultural Station, Asuansi; (c) Government Agricultural Station, Pokoasi, and (d) University College Agricultural Research Station, Nungua.

1. ACHIMOTA RESEARCH STATION*

Two distinct types of both goats and sheep were studied at this centre: (i) West African Dwarf Goat; (ii) West African Long-legged Goat; (iii) West African Dwarf Forest Sheep, and (iv) West African Long-legged Sheep. These breeds of goats and sheep constitute the main types seen in Ghana and over the greater part of West Africa generally. The West African Dwarf Goat and West African Dwarf Forest Sheep occur in the whole area of West Africa from Senegal to the Cameroons, south of latitude 14°N., whereas the West African Long-legged Goat and the West African Long-legged Sheep have their origin farther northwards into the drier interior of West Africa where they lead a nomadic mode of life, travelling many miles daily. No attempt was made at any time to control the worm infections either by rotational grazing or dosing the animals with an anthelmintic. As a consequence, the mortality rate due to high worm populations proved from time to time abnormally heavy. It is not possible, however, to state with any degree of certainty that death in all cases was due entirely to this factor since most of the animals under observation were also infected with a local strain of either *Trypanosoma vivax* or *T. congolense*. (Edwards, Judd and Squire, 1956a, 1956b). The number of goats and sheep regularly sampled for worm eggs at this centre was rather small for ascertaining with a high degree of certainty the seasonal variation in the worm-burden of these animals in West Africa, being about three dozen dwarf goats and approximately a dozen of each of the other three types of animals. Despite the low numbers studied, it will be seen from the results depicted graphically in Figs. 1 and 2 that there was a remarkable uniformity in the general pattern of the seasonal variations in the helminth population of the four types of animals based on the number of eggs present in the faeces.

*Now known as the Biological Research Institute Farm.

In each year, the number of worm eggs in the four types of animals reached the highest peak of occurrence about June but sometimes a month either earlier or later. In the Dwarf Goat, they remained at relatively high levels in 1954 from April until August, in 1955 for the two months May and June, and in 1956 from June until August. In each year, a slight peak also occurred in November or December, being particularly evident in the Dwarf Goats in November 1953, shortly after the arrival of a high proportion of them at the station from the Northern Region of Ghana. As is customary in Ghana, these goats would have been kept at night and the greater part of the day in the immediate vicinity of the homesteads in the villages where the ground is heavily contaminated with eggs and infective larvae of nematodes of various kinds. It is probable, therefore, that this fact accounts for the abnormally high egg-counts for the Dwarf Goats at the end of 1953 as compared with those for the same period in the three subsequent years when these animals were maintained under more hygienic conditions.

It would seem from these results (Figs. 1 and 2) that there are two distinct periods of the year in West Africa, namely, about June and November, at least under the conditions which existed at Achimota, Ghana, in 1953-56, when worm-egg production in goats and sheep reaches a high level compared with that at other times of the year. It is generally assumed, at least in temperate regions of the world, that climatic conditions, especially temperature, play a significant role in the seasonal variation of the worm-burden of domestic animals. It cannot be claimed, however, that temperature is an important factor in this respect in Ghana since it seldom varies more than 9°F. at any period in the year or drop below 75°F. either in the daytime or at night. The lowest temperatures are normally recorded shortly after the main rainy period, that is, in July and August, and in the harmattan weather in December and January when desiccating wind blows across West Africa from the Sahara.

It is probable, on the other hand, that rainfall is important in West Africa in connection with the seasonal variation in worm-burden of domestic animals. The annual rainfall at Achimota in 1954, 1955 and 1956 was 36·3, 49·1 and 30·6 in. respectively, and its distribution in these years is shown in Figs. 1 and 2. There are two rainy periods during the year, the main one covering normally April, May and June, and the lesser one, the little rains, about the beginning of October. By the end of November the ground has usually become too dry to maintain any longer a succulent growth of grass. During

the dry, hot period extending from November until May, an occasional shower of rain is sometimes sufficiently heavy to effect a temporary flush of new grass but normally little or no luxuriant growth is seen until the advent of the rainy season towards the end of April. It is apparent in Figs. 1 and 2 that the output of worm eggs present in the faeces of the goats and sheep at Achimota during 1954-56 followed essentially a similar trend to the rainfall, a high peak each year about June and a much smaller one about November.

There were appreciable differences in the degree of worm-burden of the various goats, judging by the number of eggs discharged in the faeces. Some goats, although showing the typical seasonal variation in worm-egg counts, never harboured heavy infections (Table 1).

TABLE I

The maximum number of nematode eggs recorded per gm. of faeces, on a monthly average basis, for moderately infected goats of the West African Dwarf breed at Achimota in 1954-56, inclusive.

Goat	1954	1955	1956
GD 3	2,700	2,500	1,950
GD 8	7,550	5,250	4,950
GD31	3,100	2,700	2,150
GD46	6,650	3,200	3,950
GD53	6,250	2,800	1,050
GD61	1,250	200	150

These results taken by themselves also point to the conclusion that in the course of the three years the resistance to worm infestation gradually increased in these moderately parasitized goats. At no time did these goats display obvious clinical symptoms.

In other dwarf goats the infection remained at a high level and, in extreme cases, ultimately reached an intensity so severe that the animal could no longer bear the burden imposed upon it by such high numbers of nematodes. Typical examples are included in Table 2.

TABLE II

The maximum number of nematode eggs recorded per gm. of faeces, on a monthly average basis, in heavily infected goats of the West African Dwarf breed at Achiomota in 1954-56, inclusive.

Goat	1954	1955	1956
GD35	3,850	17,850	23,100 (died)
GD79	8,250	13,750	17,850 (died)
GD84	3,500	4,850	26,300 (died)
GD 5	35,800 (died)		
GD34	22,900 (died)		
GD60	31,450 (died)		

Judging from the results obtained in the present studies it would appear that an index of infection exceeding 14,000 E.P.G.* in the West African Dwarf Goat presents a dangerous level of infection which is likely to lead to a pronounced lethargy, debilitation and an early death of the animal. This type of goat when fully grown and in a good condition seldom exceeds 30 lb. live weight. The West African Long-legged Goat, on the other hand, which is a considerably larger animal, weighing about 50 to 65 lb. can usually tolerate a much

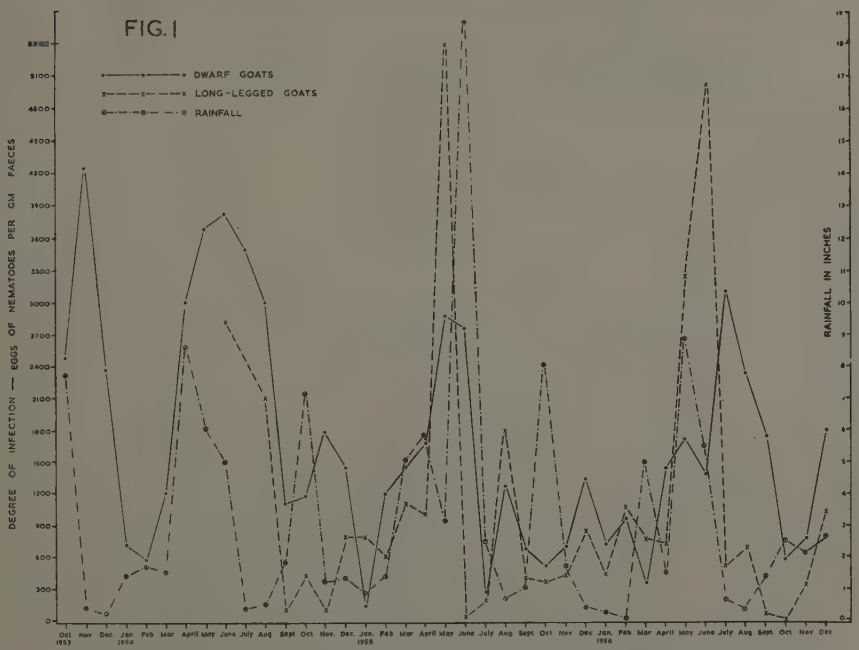

Fig. 1. The monthly average of egg counts of nematodes recorded per gm. of faeces in untreated West African Dwarf Goats and West African Long-legged Goats at Achimota, Ghana, in 1954 to 1956, inclusive ; also the monthly average rainfall recorded at the centre over the same period.

heavier infection, the critical level being in the region of 23,000 E.P.G. under the conditions in the southern part of Ghana. Both the West African Dwarf Forest Sheep and the West African Long-legged Sheep are also capable of harbouring extremely heavy infections

* Eggs per gramme of faeces.

without displaying any obviously harmful manifestations. Individuals of these two breeds have often survived despite the fact that nematode-egg production had amounted to 40,000 and 68,000 E.P.G., respectively.

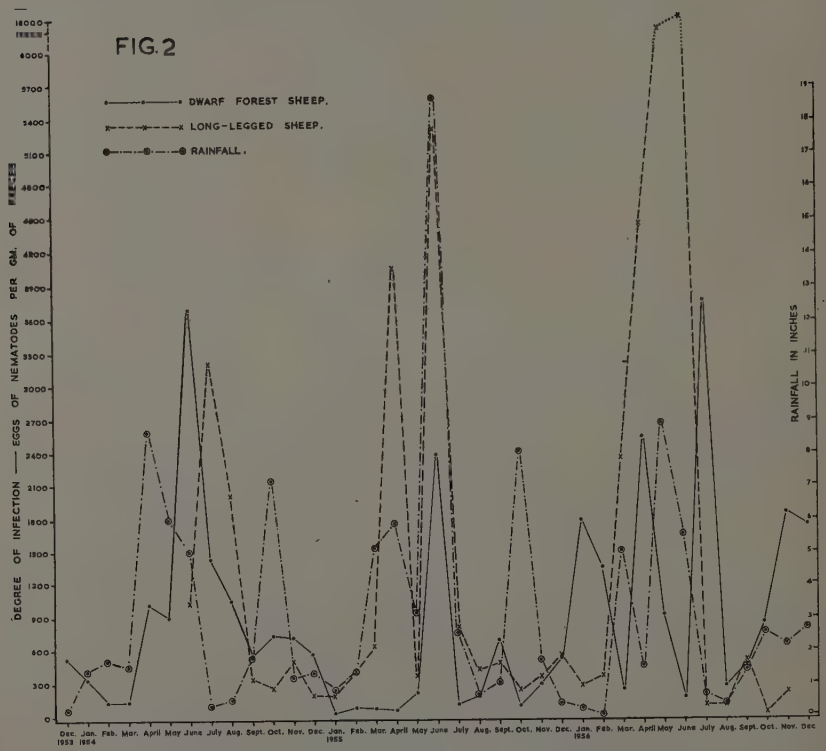

Fig. 2. The monthly average of egg-counts of nematodes recorded per gm. of faeces in untreated West African Dwarf Forest Sheep and West African Long-legged Sheep at Achimota, Ghana, in 1954 to 1956, inclusive; also the monthly average rainfall recorded at this centre over the same period.

2. ASUANSI AGRICULTURAL STATION

This centre, some 100 miles west of Achimota and about 12 miles from the coast, is situated in an area where the rainfall is higher, being in the region of 60 in. per annum, and more evenly distributed than at Achimota. The climatic conditions are essentially typical of the forest belt and conducive to good growth of herbage even at the height of the dry season. The sheep maintained at this centre consisted of the local breed, West African Dwarf Forest Sheep, which had been improved over a number of years by artificial selection. The flock was divided into three groups, each comprising about 40 sheep : (a) untreated control ; (b) dosed periodically with phenothiazine, and (c) dosed at fortnightly intervals with nicotine copper

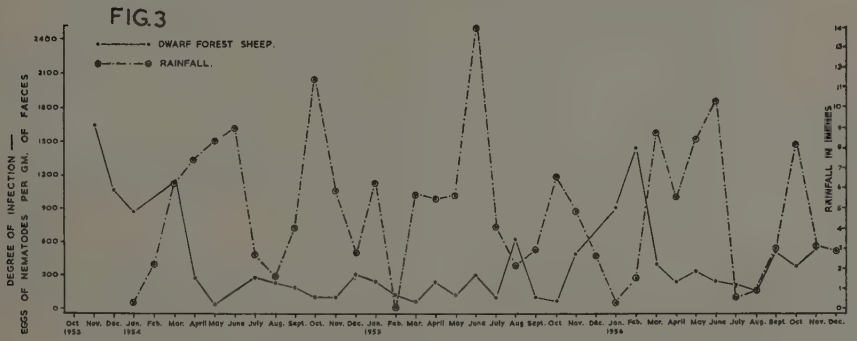

Fig. 3. The monthly average egg-counts of nematodes recorded per gm. of faeces in untreated West African Dwarf Forest Sheep at Asuansi, Ghana, in 1954 to 1956, inclusive ; also the monthly average rainfall recorded at this centre over the same period.

sulphate. The average monthly index of infection per sheep in the untreated group over a period of three years, based on the number of E.P.G. is shown graphically in Fig. 3. It will be observed from the results presented in this graph that the intensity of infection was appreciably lower than that found in the goats and sheep at Achimota and that the peaks of worm-egg production were also less evident and more irregular in respect to the time of their occurrences in the different years. These peak intensities occurred in March, July and December in 1954 ; in April, June, August and November in 1955 ; and in February, May, September, and November in 1956.

When the sheep in the untreated group were sampled in November 1953, the average egg-count per sheep was 1,650 E.P.G. Thereafter the number of eggs gradually diminished to a level in May 1954 of only 69 per gm. of faeces. The worm-egg output remained for the rest of the year at a low ebb and never exceeded, on an average basis, 300 E.P.G. even at the maximum peaks of production in July and December. Similarly in 1955, it continued at this low level except in August and November when 620 and 510 E.P.G., respectively, were recorded. The worm burden at this centre in 1956 was characterised by a marked increase in the output of eggs in the first three months of the year compared with that in the preceding 21 months and in this respect proved reminiscent of the egg-production witnessed early in 1954. For the next five months the egg-counts remained low but in September they increased to give a monthly average per sheep of 520 E.P.G. This was followed by a small reduction in October but later in the year the egg-laying rate recovered and reached a slightly higher than that in September.

TABLE III

The monthly average number of eggs of nematodes recorded per gm. of faeces per sheep in two groups of West African Dwarf Forest Sheep at Asuansi, Ghana, one untreated and the other dosed with phenothiazine, 17 gm. per animal, in November, 1953 and in January, July and September, 1954

1954	*Untreated sheep*	*Treated sheep*	1954	*Untreated sheep*	*Treated sheep*
January	877	318	October	84	69
March	1,173	490	November	92	136
April	275	252	December	189	241
May	69	139			
July	279	2,014	1955		
August	234	149	February	114	97
September	185	116	March	70	545

The group of 40 sheep dosed periodically with phenothiazine, 17 gm. to every-one of them on each occasion, behaved from time to time in a most unexpected manner after treatment in respect to worm-egg content of their faeces. The sheep were first dosed in November 1953 and again in January 1954. This resulted in 60% reduction in the number of eggs in the faeces of the dosed sheep for the first three months in 1954, compared with that in the untreated sheep. The worm-egg production then suddenly became greater in the dosed sheep than in those kept as untreated controls and by July the difference in egg-counts between these two groups of sheep amounted to 7 : 1, respectively (Table 3). The sheep in the treated

group were again dosed in July and September with the result that the number of eggs in the faeces dropped by about 30%, on an average basis, for the months August to October 1954. Towards the end of the year the beneficial effect produced by the treatment was no longer evident and the treated sheep quickly built up an infection far heavier than that in the control animals, and by March 1955 the ratio of the number of worm-eggs discharged in the faeces by the two groups of sheep was in the region of 8 : 1, respectively. The monthly average number of E.P.G. per sheep in the untreated and dosed groups is given in Table 3.

Essentially similar results were subsequently obtained by the writers at this centre and also at other centres where anthelmintic treatment was used at long intervals. These results taken by themselves indicate that once anthelmintics, such as phenothiazine, are administered and their beneficial effects are no longer evident there is a distinct tendency for the animals to become far more heavily infected than untreated animals, judging by the number of eggs in the faeces. It would seem that the natural resistance to worm infection is reduced or at least that the conditions within the host become more suitable for the parasites. It must be emphasized, however, that definite conclusions in this connexion cannot be safely drawn from these preliminary studies designed for other purposes.

3. POKOASI AGRICULTURAL STATION

Pokoasi is situated some seven miles north-east of Achimota on the borders of the forest area of the central region of Ghana and the dry Accra plains in the extreme south-eastern part of this country. The rainfall is barely sufficient there to maintain herbage in a green state throughout the whole of the dry season but it is higher and more evenly distributed than at Achimota. As at Asuansi the flock of sheep kept at this centre comprised West African Dwarf Forest type, and some improvement of it for mutton production has been effected in recent years by selective breeding. The flock was separated into two groups, each consisting of about 50 sheep, one group of untreated controls and the other periodically dosed with an anthelmintic. The average monthly index of infection per sheep in the undosed group from October 1953 to July 1955, inclusive, based on the number of E.P.G. is presented graphically in Fig. 4. Unfortunately, it was not possible to make egg-counts in some months and the survey had to be discontinued in August 1955 due partly to heavy casualties caused by heart-water (*Rickettsia ruminantium*) and partly to a change in live-stock policy at this centre.

It will be seen in the graph (Fig. 4) that, as at Asuansi, the worm-egg counts were appreciably lower than in the goats and sheep at Achimota and that the peaks of maximum egg-production were also less marked and more irregular in their seasonal distribution. It is also noteworthy that the seasonal variation in the number of eggs in the sheep faeces followed the same general pattern as that observed in the sheep at Asuansi, the peaks of production occurring in March and July 1954, and again in January and April 1955. The highest egg-counts were recorded at the end of 1953 but thereafter a gradual reduction took place and continued up to October 1954. Subsequently, there was a general increase in the number of worm eggs but it did not reach an average of 300 E.P.G. in any month up to August 1955 when the studies at this centre were terminated.

As at Asuansi, sheep dosed with anthelmintic, though usually benefiting temporarily from the treatment, ultimately became far more heavily infected than untreated sheep, as shown in Table 4.

TABLE IV

The monthly average of egg-counts of nematodes recorded per gm. of faeces in two groups of West African Dwarf Forest Sheep at Pokoasi, Ghana, one untreated and the other dosed with phenothiazine in March and June, 1954 and nicotine copper sulphate in October, 1954 and March, 1955.

1954	*Untreated sheep*	*Treated sheep*	1954	*Untreated sheep*	*Treated sheep*
March	680	580	October	19	39
May	214	429	November	50	550
June	358	562	1955		
July	392	385	January	285	2,658
August	122	2,527	February	24	1,212
September	58	1,172	April	274	111

As at Asuansi, the anthelmintic treatment was applied at long intervals but in contrast to the results obtained there, the sheep did not benefit even temporarily from the treatment except perhaps after the second dose of nicotine copper sulphate in March 1955, judging by the number of worm-eggs that continued to be passed.

4. NUNGUA AGRICULTURAL RESEARCH STATION

The Agricultural Research Station of the Faculty of Agriculture of the University College of Ghana is situated some 14 miles east of Achimota on the arid Accra Plains near the coast. It was established

in 1951 on land which had never been brought under farming conditions as it was regarded as being far too dry for the greater part of the year for the purpose. There is a stream flowing through the area during the rainy period of the year, normally April to June, inclusive, and afterwards for a few weeks. Crop and animal husbandry was made possible here by constructing a large dam to provide an adequate supply of water for these purposes throughout the long dry season which usually extends from October until about May. The cattle, sheep and other farm stock are allowed to graze freely over enclosures of pastureland composed largely of indigenous grasses. Their diet is supplemented from time to time with cultivated green fodder.

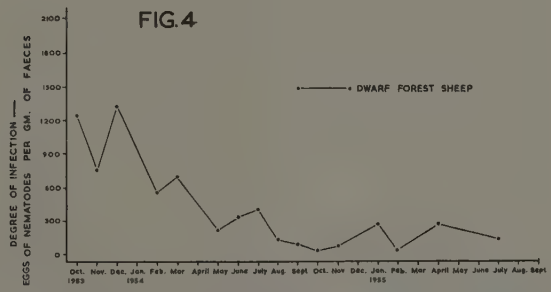

Fig. 4. The monthly average egg-counts of nematodes recorded per gm. of faeces in untreated West African Dwarf Forest Sheep at Pokoasi, Ghana, from October 1953 to July 1955.

The local breeds of farm animals in Ghana are exceedingly small in size and slow in reaching maturity. Serious attempts are being made at this Research Station to improve these animals by selective breeding and by crossing with animals of appropriate types imported specially for the purpose from Great Britain, South Africa and other regions in Africa. As regards sheep, importations of rams and ewes of the Wiltshire breed from Great Britain and of the Black-headed Persian breed from South Africa were made in 1953 and 1954, respectively. Advantage was taken of the opportunity to find out if these new breeds of sheep to West Africa and their crosses with the local breed, West African Dwarf Forest Sheep, are more liable than the local breeds of sheep to heavy infections of the prevalent species of nematodes and tapeworms found in Ghana.

The Wiltshire sheep when examined at the end of 1953, some ten to fourteen weeks after importation to Ghana had, on a monthly average, a worm-egg count per sheep of 492 and 918 E.P.G. for December 1953 and January 1954 compared with 238 and 261, respectively, for the West African Dwarf Forest Sheep. Further comparative indices of infection of these two breeds of sheep are not available as it became imperative to protect by all possible measures these valuable Wiltshire sheep imported for cross-breeding purposes, from infection by worms, protozoa and bacteria of various kinds.

The Persian sheep were also examined shortly after their arrival in Ghana for evidence of increased worm infection. It soon became apparent that the sheep were rapidly becoming more heavily infected. In November 1954, that is, about ten weeks after arrival in Ghana, their average worm egg counts were 2,133 E.P.G. compared with 536 for ewes of the West African Dwarf Forest Sheep. In February 1955, the egg counts for the Persian sheep had increased, on an average basis, to 13,225 while that for the local breed, though higher than in November, was only 692. As in the case of the Wiltshire sheep, further comparisons are not available as it became essential to adopt all possible means of bringing under control the worm and other infections.

Worm-egg counts of the Persian cross-bred lambs (Persian × West African Dwarf Sheep) were commenced as soon as they were weaned in August 1955. It was found they already harboured exceptionally heavy infestations of nematodes, that is, they had within four to five months of birth, an on average, 11,430 E.P.G. It is also noteworthy that this flock of some 70 Persian cross-bred lambs showed a wide variation in their worm-egg counts but all had eggs in their faeces, several upwards of 23,000 per gm. Further, almost all of them carried tapeworms which had already reached maturity. It was revealed at post-mortem examinations that the tapeworms were invariably *Moniezia expansa*. Ewes of the West African Dwarf Forest Sheep grazing on the same ground as the Persian Cross-bred lambs had in August 1955 an average per sheep of only 182 eggs of nematodes per gm. of faeces. Further comparative data in this respect are not available as the entire Persian Cross-bred flock was carefully and frequently dosed with anthelmintics with fairly successful results.

An opportunity presented itself in July 1956 for comparing the degree of infection by nematodes in young Persian Cross-bred lambs

(Persian × W.A.D.F. Sheep), Wiltshire Cross-bred lambs (Wiltshire × W.A.D.F. Sheep) and in the lambs and ewes of the W.A. Dwarf Forest Sheep. The average index of infection per animal in these different groups, was 17,412 E.P.G. for the Persian Cross-bred lambs ; 19,647 for the Wiltshire Cross-bred lambs ; 4,364 for the lambs of the West African Dwarf Sheep and 407 for the ewes of this latter local breed. The fact that lambs are more susceptible to heavy infections of nematodes than ewes even in the local breed, the West African Dwarf Forest Sheep which has never been the subject of any crossing with other breeds for improvement purposes is further confirmed by the indexes of infection obtained in March, May, September and November 1956.

TABLE V

The monthly average of egg-counts of nematodes recorded per gm. of faeces in ewes and lambs of the West African Dwarf Forest Sheep at the Agricultural Research Station of the University College of Ghana in 1956.

Month	*Ewes*	*Lambs*
March	106	3,117
May	245	4,900
July	407	4,364
September	397	2,434
November	241	2,164

Additional information in respect to relative degree of infection of ewes and lambs was also obtained at the Government Veterinary Farm which adjoins the Nungua Agricultural Research Station. A flock of about 40 ewes of Long-legged West African Sheep was assembled there late in 1955. Both the ewes and their lambs born between January and September 1956 were sampled for worm eggs at bi-monthly intervals from March 1956 to May 1957, inclusive. The flock was not confined to enclosed fields but allowed during the day to graze extensively over uncultivated land. Each evening the sheep were placed in a kraal and offered wet brewer's grains obtained from the local brewery. The kraal was not littered and the sheep remained there overnight, resting on ground covered with their own dried droppings. Counts of eggs of both the nematodes and tapeworms (*Moniezia expansa*) present in the faeces of the ewes and also of their lambs were made. The results are given in Table 6.

These results point to the conclusion, in the case of this West African breed of sheep, that (a) lambs, as expected, carry a far heavier worm-burden than adult sheep, (b) a high degree of resistance to nematode infestation is rapidly developed by lambs with increase

in age and (c) a far higher proportion of lambs than ewes harbour tapeworms and as they get older the infection tends to diminish.

TABLE VI

The average number of eggs of nematodes recorded per gm. of faeces at bimonthly intervals in ewes and lambs of the West African Long-legged Sheep at the Government Vetinerary Farm, Nungua, Ghana, and also the percentage of the ewes and lambs found with eggs of the tapeworm Moniezia expansa *in their faeces.*

	Nematode eggs per gm. faeces		*Tapeworm eggs per cent infected*	
1956	*Ewes*	*Lambs*	*Ewes*	*Lambs*
March	108	2,779	8	80
May	253	4,319	8	55
July	405	3,489	2	32
September	389	2,476	6	54
November	250	2,068	4	20
1957				
January	355	272	11	25
March	100	279	3	20
May	618	514	8	11

SUMMARY AND CONCLUSIONS

An account is given of the results of preliminary studies of the worm-burden of goats and sheep in Ghana, West Africa, based on fortnightly counts of nematode eggs in their faeces over a period of three years, 1954 to 1956, inclusive. Only eggs of nematodes and *Moniezia expansa* were encountered apart from an occasional egg of *Schistosoma* sp., probably *S. bovis*, in two sheep. Four centres were involved in these investigations differing appreciably in regard to the amount and distribution of the rainfall. It would seem from the results obtained that :—

(a) There are in the drier regions two distinct periods in the year when worm-egg production in goats and sheep reaches a high level compared with that at other times of the year, a high peak of production in June, sometimes a month either earlier or later, and a slight peak in November or December.

(b) There are seasonal variations in the forest belt regions but here the peaks of egg-production are less evident and more irregular in respect to the time of their occurrences in different years.

(c) Rainfall constitutes an important factor in connection with the seasonal variations in worm-burden of domestic animals in West

Africa, at least in Ghana. In the dry coastal belt of Ghana two rainy periods occur during the year, the main one normally covering April, May and June, and the minor one about October. The output of worm-eggs present in the faeces of animals in this region follows essentially a similar trend with a very high peak of production each year about June and another, but of a much lower level, about November. In the forest belt regions, the climatic conditions due largely to a higher and better distributed rainfall are conductive, in contrast to the dry coastal plains, to good growth of herbage throughout the year. Seasonal variations in the worm-burden of animals, in so far as it is revealed by the eggs passed in the faeces, do also occur here but they are far less pronounced and more irregular.

(d) Although temperature is generally recognized as a significant factor in seasonal variations of worm-burden of domestic animals, it appears to be unimportant in Ghana. Seasonal differences in worm-egg counts do occur even in the southern part where the shade temperature remains remarkably constant, seldom varying more than 9°F. or dropping below 75°F. at any time of the year, either in the daytime or at night.

(e) The two common races of both goats and sheep in West Africa, (i) West African Dwarf Goat, (ii) West African Long-legged Goat, (iii) West African Dwarf Forest Sheep and (iv) West African Long-legged Sheep, can tolerate heavy worm-burdens. Dangerous levels of infection, when death is likely to ensue, are attained in the two races of goats when the number of eggs exceeds 14,000 and 23,000 per gm. of faeces, respectively. The two races of sheep can also withstand extremely high infections without displaying serious clinical symptoms. Some individuals of these two types in the present studies survived even when the worm-egg output amounted to about 40,000 and 68,000 per gm. of faeces, respectively.

(f) Goats and sheep of the indigenous breeds in Ghana are liable to become heavily infected with nematodes early in life but normally in the course of the first year from birth they build up a resistance and the degree of infection thereafter gradually diminishes until it is no longer a grave danger to the survival of the animal. As a rule, this ability to surmount nematode infections is, however, only possible where the worm population in the early life of the animal is well below the aforementioned dangerous levels.

(g) Sheep imported into Ghana for improvement of the indigenous races for mutton production, namely, Wiltshire and Black-headed Persian breeds from Great Britain and South Africa, respectively,

have proved more susceptible to heavy worm-infections than the two local types of sheep. The progeny obtained by crossing these two imported breeds with the local races have also proved liable to heavier attacks than the native sheep.

Acknowledgments

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On *Probstmayria reptiliae* n. sp., from *Homopus femoralis* and Some Notes on the Genus *Probstmayria*

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This worm was very abundant in the rectum of a tortoise, *Homopus femoralis*, from the Bloemfontein area, Orange Free State, South Africa. It was found together with several other oxyurids the description of which will form the subject of a later paper. Although the *Probstmayria* far exceeded the other oxyurids in number, male specimens of this genus were extremely rare for only one male was found after a prolonged search during the course of which many hundreds of females were encountered. In order that no specimens should be lost the entire alimentary canal together with its contents was submerged in hot 70% alcohol after scraping the mucosa.

This record is of particular interest since it is the first one of a member of the genus *Probstmayria* from a reptilian host. Previous records of this genus have been from equines and the higher apes.

Probstmayria reptiliae n. sp.

The cuticle is very finely striated transversely. There are six somewhat pear-shaped clearly-defined lips distinctly set off from the body by a constriction. Each lip bears a papilla at its extremity. Internally there are a number of knob-like protrusions which appear to be prolongations of the pharyngeal cuticle. The lips attain a length of about 6–7μ.

The vestibule, or pharynx, is 0·046 to 0·052 mm. in length and about 6–9μ in diameter. At its anterior extremity it increases somewhat in external diameter because of a sudden thickening of the cuticle. The diameter of the lumen remains constant throughout its length. Its walls are relatively thick and they widen posteriorly to merge with the muscular walls of the oesophagus. The lengths of the pharynx and the oesophagus are in the proportion of about 1 : 6.

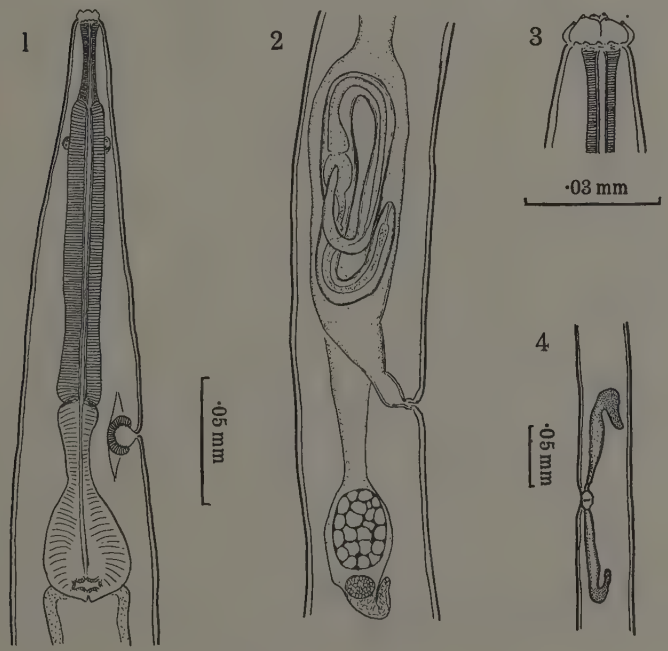
The pharynx and the oesophagus are typical of the genus. The oesophagus consists of two parts. The anterior cylindrical portion is stout, straight and 0·14 to 0·21 mm. in length and 0·019 to 0·022 mm. in diameter, ending posteriorly in a very slight swelling and divided by a constriction from the less broad swelling of the anterior extremity of the second part of the oesophagus. The latter posterior part of the oesophagus is flask-shaped and 0·090 to 0·095 mm. in length. The transverse diameter of its large posterior bulb is 0·041 to 0·048 mm. and the "neck" of the "flask" at its narrowest is 0·011 to 0·014 mm. in diameter. The large bulb is furnished with the usual valvular apparatus and, as observed by Maplestone in *P. simiae*, the cusps are covered with fine concentric ridges which may serve as food grinders. The nerve ring surrounds the first part of the oesophagus in its anterior half and is situated 0·077 to 0·1 mm. from the anterior extremity of the worm.

The excretory pore opens in front of the oesophageal bulb and just posterior to the junction of the anterior and posterior sections of the oesophagus from 0·209 to 0·300 mm. from the anterior extremity. It is large and conspicuous, consisting of a globular vesicle surrounded medially by a striated cortex which is kidney shaped in optical section and which bears striations which radiate from the vesicle.

The female is about the same size as and somewhat shorter than the male. The female tail is more or less straight, that of the male is permanently hooked, so that the sexes are easily distinguished.

Female.—Straight, fusiform, tapering from the centre to both ends. Specimens containing embryos measured 1·36 to 1·53 mm. in length and 0·059 to 0·067 mm. in diameter. The vulva is invariably in the posterior half of the body and is situated from 58·5% to 60·5% from the anterior end when the total length of the worm is taken as 100%. The vulva has hardly any lips and protrudes only very slightly into a shallow saucer-shaped depression of the body wall which surrounds it. The vagina is very short and thin-walled and runs forward from the vulva in mature specimens. The tail is straight or frequently curved dorsally in alcohol-fixed specimens. It is comparatively short and its length when measured in proportion to the total body length is about 1 : 14. In adult females it is from 0·108 to 0·132 mm. long when measured from the anus to its tip. The termination of the intestine is marked by three large rectal glands which are turned forwards. The rectum is lined with very thick cuticle and its walls are of a characteristic shape so that at

first glance they could be mistaken for a pair of equal spicules when viewed from the lateral aspect. The uterus is characteristic of the genus, consisting of two divergent branches which lie almost in a straight line with the vulva at mid point and the ovaries curving

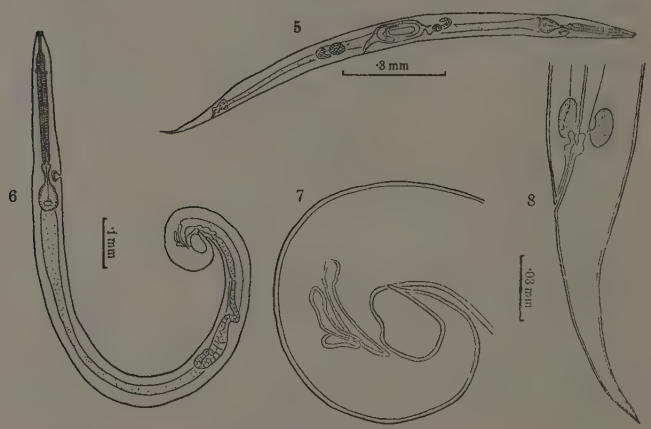


Probstmayria reptiliae n.sp.

1. Anterior extremity, lateral view. 2. Mature female, central position of body, to show appearance of genitalia and embryo in detail. Lateral view. 3. Cephalic extremity showing disposition of lips and part of pharynx or vestibule. 4. Immature female, central position of body, to show appearance of genitalia. Lateral view.

dorsally in immature specimens. In mature females one, or less frequently two, well-developed coiled embryos occupy the central portion ; next to this, more distally is a morula with one or two immature eggs near it. The oesophagus of the embryo is of the adult type and well-developed.

Male.—The male is ventrally curved in its posterior half and the tail is permanently hooked. It measures 1·6 mm. in length and has a maximum diameter of 0·058 mm. at the level of the oesophageal bulb. The tail tapers to a point and measured from the cloaca is about 0·136 mm. in length. It has not been possible to make out any distinct caudal papillae in the specimen available. The spicules are unequal and dissimilar. When viewed from the lateral aspect the longer left spicule has a somewhat rectangular head or proximal



Probstmayria reptiliae n.sp.

5. Mature female, lateral view. 6. Male, lateral view. 7. Posterior extremity of male, lateral view, to show position of spicules and gubernaculum. 8. Posterior extremity of female, lateral view, showing rectum, rectal glands and position of intestine.

end, is more slender and more gracefully curved than the shorter right spicule and resembles a sabre blade. It is 0·071 mm. in length measured down the middle and along the curve and has a maximum width of about 5μ. The shorter right spicule has a more or less oval head, is a little thicker and more acutely curved. It is 0·041 mm. long measured in the same way as the left spicule and has a maximum width of about 6μ. Boht spicules have their proximal heads set off by necks and both terminate distally in a fairly abrupt point. A gubernaculum is present. It is roughly triangular and more or less saddle-shaped with the seat of the saddle directed ventrally, the flap dorsally, and the low pommel and high cantle anteriorly and

posteriorly respectively. It is relatively much larger than that of *P. gorillae* Kreis. The testicle is single and reaches as far as 0·91 mm. from the anterior extremity of the worm. It turns sharply and runs in a posterior direction for a short distance of 0·04 mm. at its anterior extremity. It is at its thickest anteriorly just before it curves back and its diameter here is about 0·033 mm. As it runs in the direction of the cloaca it narrows and terminates in what appears to be a thin-walled seminal vesicle.

RELATIONSHIPS

The characteristic head, lips, pharynx and oesophagus, male and female sexual organs and method of reproduction place this worm without any doubt in the genus *Probstmayria* Ransom, 1907. With unequal spicules as in *P. simiae* Maplestone, 1931 and the presence of a gubernaculum as in *P. gorillae* Kreis, 1955 and the comparatively small size of both it seems obvious that the species under consideration occupies a position between both these worms of simian origin. It differs from all species yet described in that it has unequal bent spicules and a gubernaculum and that in the female the vulva occupies a position posterior to the mid-point of the body. For these reasons it is considered that this worm is without doubt a new species and it is proposed to name it *Probstmayria reptiliae*, n.sp., because of its occurrence in a reptilian host.

A KEY TO THE SPECIES OF THE GENUS *PROBSTMAYRIA*

1. Gubernaculum absent 2
   Gubernaculum present 3

2. Adult female longer than 3 mm.; male longer than 2·5 mm.; spicules subequal and similar ... ... *P. vivipara*
   Adult female not longer than 1·8 mm.; male not longer than 1·6 mm. spicules unequal and dissimilar ... ... *P. simiae*

3. Vulva in front of mid-body; spicules subequal and similar *P. gorillae*
   Vulva behind mid-body; spicules unequal and dissimilar *P. reptiliae*

STATUS OF THE GENUS

That the genus *Probstmayria* belongs to the super-family Oxyuroidea is certain because of its oesophageal bulb containing a denticular apparatus. It may be argued that the school of thought which assigns the genus to the family Kathlaniidae (Baylis 1923, Baylis and Daubney 1926, Cameron 1951) has gained strength by the fact that a representative has now been found in a cold-blooded host since that family contains exclusively parasites of cold-blooded animals (provided that the genus *Cruzia* is placed in its own family Cruziidae). If, however, one is to place more reliance on arguments founded on a morphological basis, then the advocates of placing the genus in the family Oxyuridae (Travassos, 1919; Yorke and Maplestone, 1926; Neveu-Lemaire, 1936) have been strengthened. The most outstanding features of the Kathlaniidae are the three well-developed lips and the well-developed precloacal musculature of the male frequently forming a sucker. The genus *Probstmayria* shows neither of these features. No special adaptation of the precloacal musculature of the male has been noted in any of the four species so far described. There is a difference of opinion as to whether *P. vivipara* has six or three bilobed lips. Maplestone, 1931 describes *P. simiae* as having "six large semi-globular (or three bilobed lips) each containing a central pointed core". Kreis (1955) appears to be quite certain that both *P. vivipara* and his *P. gorillae* possess six well-defined lips. The lips of *P. reptiliae* show no sign of being bilobed but are clearly six in number. The structure of the oesophagus is remarkably constant in all species of the genus *Probstmayria* and there is no evidence of the single true prebulbar swelling which characterises so many of the members of the family Kathlaniidae.

It is suggested that the diagnosis of the family Oxyuridae as given by Yorke and Maplestone, 1926, should be modified to read "two equal, subequal, or unequal spicules" instead of "two equal spicules" under the definition of the male.

The finding of a gubernaculum in the presence of two spicules and a pharynx or vestibule in *P. reptiliae* lends support to the creation by Kreis (1955) of a new subfamily Probstmayriinae for the reception of the genus *Probstmayria* based on such findings in *P. gorillae*. Thus while the possession of two spicules is common to the subfamilies Cosmocercinae, Oxysomatiinae, and Probstmayriinae and serves to distinguish them from the subfamilies Syphaciinae and Oxyurinae of the family Oxyuridae, the Probstmayriinae differ

from the other two in having a vestibule or pharynx and in particular from the Oxysomatiinae in which their members were previously placed, by sometimes having a gubernaculum, sometimes unequal, and never winged, spicules.

When Kreis wrote his new generic diagnosis in 1955 it is possible that he was not aware of the discovery of *P. simiae* by Maplestone in 1931. In view of the inequality and dissimilarity of the spicules in both *P. simiae* and *P. reptiliae* and the fact that previous authors have always referred to the spicules of *P. vivipara* as being subequal it is unfortunate that Kreis describes the spicules of the genus as being "gleich". I suggest that the generic diagnosis as given by Yorke and Maplestone, 1926, be modified as follows :

Probstmayria Ransom, 1907

Probstmayriinae Kreis, 1955

Generic diagnosis : Small nematodes ; mouth small, surrounded by six lips ; cuticle without lateral flanges ; a cylindrical vestibule or pharynx present ; oesophagus consisting of two tandem parts separated by a transverse groove, the anterior part being long and straight, the posterior part characteristically flask-shaped and terminating in a bulb furnished with a valvular apparatus. The tail in both sexes is long and pointed, the anus lying at the commencement of the tail some distance from the posterior extremity. *Male* : posterior extremity curved but not spirally rolled ; caudal alae absent ; about six pairs of postanal papillae ; spicules equal, subequal or unequal, similar or dissimilar ; gubernaculum absent or present. *Female* : vulva in posterior or anterior half of the body but always near the middle of the body ; the two uteri contain eggs and free embryos. Viviparous. Parasites of equine animals, gibbons, gorillas and tortoises.

Type species : *P. vivipara* (Probstmayr, 1865). Male 2·7 mm., female 3·4 mm. In intestine of equine animals. Syn., *Oxyuris vivipara* Probstmayr, 1865.

Other species : *P. simiae* Maplestone, 1931 from *Hylobates hoolock* ; *P. gorillae* Kreis, 1955 from *Gorilla gorilla* and *Hylobates concolor* ; *P. reptiliae* n.sp. from *Homopus femoralis*.

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Preliminary Observations on the Colorimetric Assay of the Hatching Factor of the Potato-root Eelworm, *Heterodera rostochiensis* Wollenweber

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In view of the possible lactone nature of the potato-root eelworm hatching factor (Marrian, Russell, Todd and Waring, 1949 ; Ellenby and Gilbert, 1957 ; Ellenby, 1958a), it seemed worthwhile to explore the possibility of assaying it colorimetrically by the methods used for the cardiac glycosides. The present communication reports on the results obtained with the alkaline picric acid and 3:5-dinitro-benzoic acid methods, principally the former. Tests have also been carried out with ammonium molybdate-sulphuric acid (Froehde's test, Martindale, 1943) and with an iodine method. The former reagent gives a deep blue or greenish blue colour with hatching solutions but appears to be satisfactory over only a restricted range of concentrations. The iodine method depends on the fact that hatching solutions show peroxide activity under certain conditions (Ellenby, 1958a) ; however, although the method is very sensitive, it has not yet proved possible to standardize the peroxide conversion.

Solutions tested were all obtained by standing the well-washed roots of actively growing potato plants in high-grade ion exchange water for 24 hours (Ellenby, 1958b). Colorimetric determinations were carried out with a Unicam Spectrophotometer using 1 cm. cells.

Experiments

Picric Acid

The picric acid reagent is a mixture of 95 ml. of 1% picric acid and 5 ml. of 10% sodium hydroxide. In a standard procedure for cardiac glycosides (Rowson, 1952), this is added to the alcoholic glycoside solution of leaf extract after a preliminary decolorisation. The orange

colour develops very rapidly, reaching a maximum in 10 minutes and remaining constant for a further 20 minutes before fading. First suggested in 1922 (Knudson and Dresbach, 1922), the method has been the subject of a great deal of criticism. It has recently been shown that both alcohol concentration and the preliminary decolorisation process can influence the result, but that, if carried out under carefully controlled conditions, the method can give concordant results (Rowson, 1952).

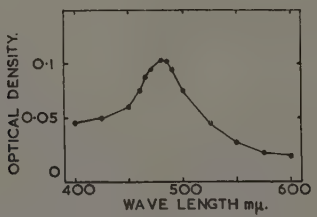

Fig. 1. Absorbtion spectrum—alkaline picric acid and solution containing hatching factor.

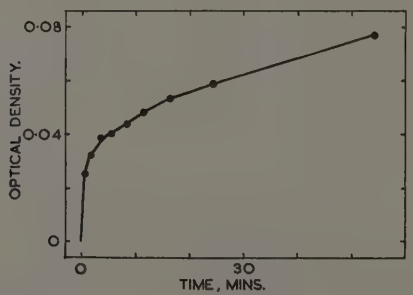

Fig. 2. Alkaline picric acid and hatching factor. Increase in optical density with time.

For the hatching factor assay, aqueous diffusate solutions were employed ; the preliminary decolorisation process was unnecessary. It was found best to add 1 ml. of the picric acid reagent to 2 ml. of the test solution, and the mixture was compared with a blank consisting of 1 ml. of reagent and 2 ml. of distilled water. The absorption

spectrum (Fig. 1) shows a single peak at 480 mμ compared with the 485 mμ for the digitalis tinctures of 3.5% ethanol content (Rowson, 1952).

Due, presumably, at least in part, to the aqueous nature of the present solutions, the colour develops slowly, as shown in Fig. 2; in fact, it is still developing between 24-48 hours after mixing. Satisfactory comparative results, however, have been obtained after 1 hour; Fig. 3 shows the results of such an assay of a series of dilutions of a three-fold diffusate concentrate. Clearly, the Beer-Lambert law is obeyed.

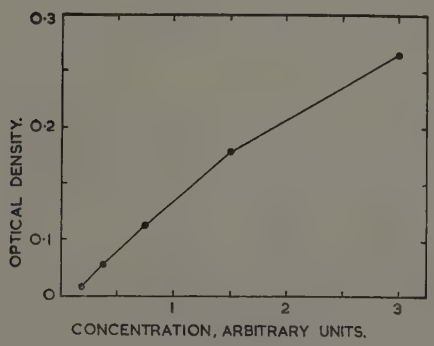

Fig. 3. Picric acid assay of a series of concentrations of a root diffusate solution. Strength of original solution, 1 arbitrary unit.

Presumably, for plants of the same variety at the same stage of growth, the rate of hatching factor production would be proportional to root weight. The validity of the method was therefore further tested by examining the diffusates of a series of plants; Fig. 4 shows good agreement between 1 hour assay values and the root weights of seven young Arran Banner plants. Nevertheless, it is undesirable to assay before maximum colour has been developed and the possibility of increasing the rate of the reaction is being examined.

3 : 5-*dinitro-benzoic acid.*

For the cardiac glycosides, the recommended method (Rowson, 1952 ; Rowson and Dyer, 1952 ; Rowson, 1955) involves a preliminary decolorisation, and then the addition of a 2% ethanolic solution of 3 : 5-dinitro-benzoic acid to the ethanolic (50%) solution of digitoxin or digitalis leaf extract ; *N* sodium hydroxide solution is then added to the mixture. With the concentrations employed, the colour develops to its maximum in six minutes, remains constant for twelve minutes, and then fades progressively. Assay is carried out at 535 or 670 mμ. Th reaction is influenced by temperature, and by the concentration of the reagents, particularly that of the alkali (Rowson, 1955).

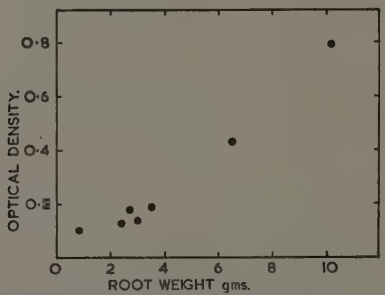

Fig. 4. Picric acid assay of solutions of root diffusate from seven Arran Banner potato plants of known root weight.

With the aqueous solutions of hatching factor employed, again without the unnecessary decoloration process, the reaction develops more slowly. As shown elsewhere (Ellenby, 1958a), the only peak is at 385-390 mμ a peak which, though given by digitoxin solutions, has hitherto evidently been overlooked. In an attempt to increase the rate of the reaction, the concentration of alkali was increased but the optical density was still increasing after one hour. Fig. 5 shows the results of an assay of a series of dilutions of the three-fold concentrated diffusate solution, using 2 ml. of the aqueous test solution 2 ml. of 2% ethanolic 3 : 5-dinitro-benzoic acid, and 1 ml. of 2 *N* sodium hydroxide solution. Readings were taken at 385 mμ after incubating at 22°C for one hour. The departure from a straight line is probably due to the rate of reaction varying with concentration of

the reacting substances, so that maximum colour is developed at different times. As for the picric acid test, it is hoped that this difficulty may be overcome so that assay at maximum development may be possible. In spite of this short-coming, however, the method

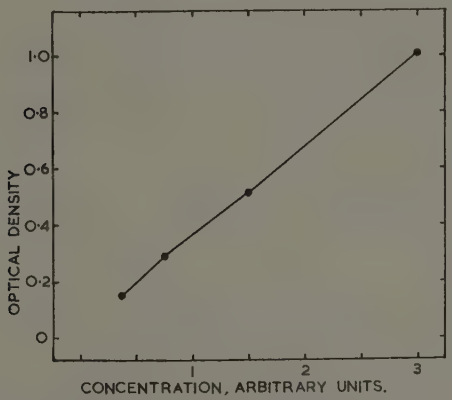

Fig. 5. 3 : 5-Dinitro benzoic acid assay of a series of concentrations of a root diffusate solution. Strength of original solution, 1 arbitrary unit.

TABLE I

Picric acid and 3 : 5-dinitro-benzoic acid assays of root diffusates of nine young Arran Banner plants. Root weights and assay values expressed as percentages of values for plant of root weight 3·5 g.

Root weight, g.	Root weight per cent	Picric acid per cent	3 : 5 Dinitro-benzoic acid assay, per cent
0·9	26	55	33
2·4	69	70	40
2·7	72	95	86
3·0	89	76	57
3·5	100	100	100
6·5	186	237	180
10·2	293	434	368

has given useful results. Table I shows a comparison of the results of picric acid, and 3 : 5-dinitro-benzoic acid, assays of the seven Arran Banner root diffusate solutions. The plants have been arranged in order of increasing root weight and, for the comparison, the values for a plant of medium size, of root weight 3·5 g., has been counted as 100. Agreement between the assay methods is reasonable, and both methods place the solutions in the same order of increasing strength.

Agreement with biological assay.

During the 1957 growing season, the picric acid method has been used on numerous occasions and has given reliable information about the relative strengths of diffusate solutions for the purposes of the development of the frog-heart assay method (Ellenby and Gilbert, 1957) and for hatching experiments. A detailed comparison of the chemical, heart, and hatching assay methods was also carried out using a root diffusate solution of low ion content (Ellenby, 1958b) and a sample of a solid concentrate prepared by the Cambridge workers (Calam, Raistrick and Todd, 1949).

1. Picric acid assay, carried out at one hour, showed the diffusate solution to be equal to a solution of the Cambridge preparation containing 1·1 mg./ml.

2. Assay on ten frog hearts, showed that a detectable effect could still be obtained with a 13-fold dilution of the diffusate solution. As the minimal concentration of the Cambridge preparation had already been found to be 0·18 mg./ml. (seventeen hearts), the diffusate was, apparently equal to a solution containing 2·3 mg. of this preparation per ml.

3. Hatching assay essentially followed the method of Fenwick (1952), total hatch being determined for a geometric series of dilutions : as total hatch is generally proportional to log. concentration, it is possible to estimate the relative strengths of different solutions.

Two hatching experiments were carried out, in June and July 1957. The first showed the diffusate to be almost 45 times and the second about 24 times as strong as the normal hatching solution of Cambridge solid ; that is, in the two cases, a 45-fold, or a 24-fold dilution, respectively would stimulate as much hatching as the normal dilution of Cambridge solid, containing 0·04 mg./ml. On the first test, therefore the diffusate appeared to be equal to a solution containing 1·8, and on the second, 1·0 mg./ml. The difference between the two estimates is largely due to low hatchings in the Cambridge solutions in the first test.

The results for the three assay methods are therefore in good agreement, the relative values being 1.1 for picric acid, 2·3 for heart assay, and 1·8 and 1·0 for hatching assays.

DISCUSSION

The chemical tests employed in the present work were selected on the assumption that the hatching factor is lactonic. But the chemical evidence supporting this is by no means decisive (Marrian, Russell, Todd, and Waring, 1949) ; nor is the physiological evidence (Ellenby and Gilbert, 1957 ; Ellenby, 1958a). Plants grown in culture solution for some weeks have been shown to give off a variety of substances, known and unknown (Lyon and Wilson, 1922 ; Katznelson, Rouatt and Payne, 1955), and although it is possible that the roots may not behave in quite the same way during the 24 hours they stood in water, the diffusates would certainly contain a number of different substances. These might influence the tests, positively or negatively ; indeed, since the nature of the hatching factor is really unknown, they may even be entirely responsible for the various tests for, presumably, they also would be given off in proportion to root weight. Moreover, the three assay methods might be differently affected by accompanying substances. For example, though the heart is very sensitive to Ca^{++}, the picric acid assay method was found to be unaffected, at least over the range of concentration 20—1mM.; but even lower concentrations of this ion in the presence of hatching factor may double hatching and thus suggest that the concentration of factor in a solution is possibly five times its true strength (Ellenby and Gilbert, in press).

The possibility that other substances may influence the assay methods makes the comparison of the Cambridge solid and the "raw" potato root diffusate of particular importance. The former was obtained from tomato root diffusates, and, moreover, the process by which it was prepared, absorption on charcoal and subsequent acetone elution and evaporation, would undoubtedly bring about some separation of the factor from accompanying substances ; the good agreement between chemical, heart, and hatching assays is therefore encouraging. Nevertheless, it would be a mistake, at this stage, to regard the chemical tests as being other than of an empirical nature and much more extensive evidence will be necessary before they can be regarded as established.

SUMMARY

Promising results in the colorimetric assay of potato-root eelworm hatching factor have been obtained with picric acid and with 3 : 5-dinitrobenzoic acid. Both of the reagents are used for the assay of cardiac glycosides with which the hatching factor may have affinities.

ACKNOWLEDGMENTS

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On a New Filarioid Worm, *Chiropterofilaria brevicaudata* gen. et sp. nov. from the Fruit Bat, *Pteropus hawaiiensis* from Fiji

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C. B. Symes,
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and J. U. Mataika
Medical Department, Fiji

A number of adult filarioids were collected by two of us (C.B.S. and J.U.M.) from the peritoneal cavity of Fruit Bats, *Pteropus hawaiiensis* in Fiji, and two kinds of microfilariae were recovered from the peripheral blood. These were brought to London for further study. The adult worm and its corresponding microfilaria in the blood were found to be of an undescribed genus and species. The other microfilaria has been studied and its various developmental stages in the mosquito have been worked out ; the results will be published later.

Chiropterofilaria brevicaudata gen. et sp. nov.

The following are the measurements of three males and four females.

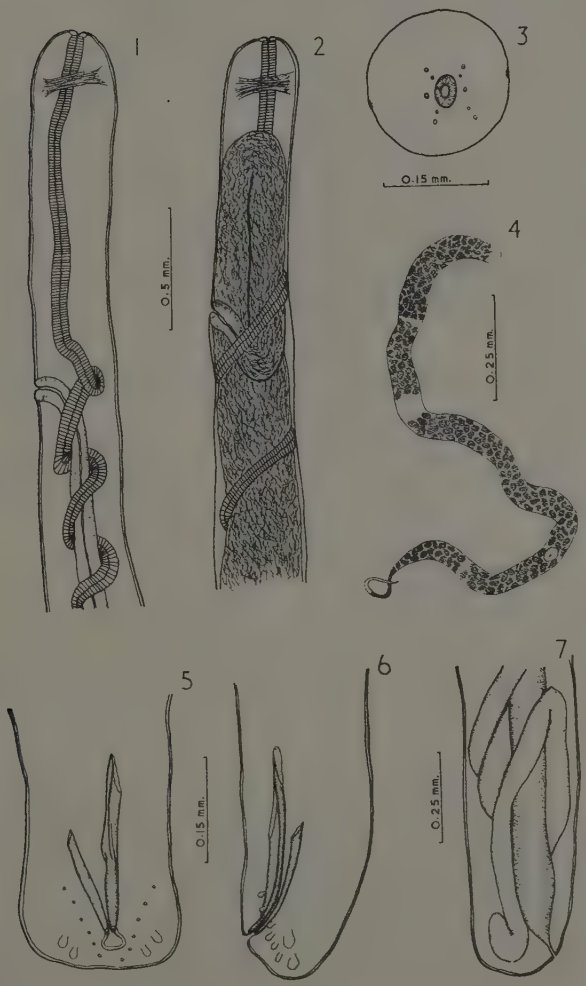
Male.			
Length	18·5 mm.	18·0 mm.	19·8 mm.
Breadth	0·31	0·27	0·30
Nerve ring	0·16	0·20	0·19
Oesophagus	3·8	4·6	4·9
Right spicule	0·15	0·17	0·16
Left spicule	0·27	0·28	0·27

Female.				
Length	32·5 mm.	29·4 mm.	26·0 mm.	25·0 mm.
Breadth	0·42	0·36	0·38	0·38
Nerve ring	0·15	0·16	0·16	0·18
Oesophagus/intestine (junction from mouth)	5·0	4·8	4·7	—
Vulva	1·4	1·3	1·4	1·3

The worms of both sexes have their extremities sharply truncated. The body cuticle is unstriated and smooth throughout. The cephalic end has a pair of lateral amphids and a complement of eight papillae. These papillae are submedian in position with four in the inner circle and four in the outer circle. The buccal opening is slightly cuticularised in the form of a ring.

Male : The principal dimensions of the three adult males are given above. The oesophagus is long and slender. The cloacal opening is subterminal. The caudal extremity is furnished with two rows of papillae on each side. The inner row consists of six small papillae on each side, while the outer row has only two large papillae on each side ; these papillae are far posterior and are only visible when a worm is fully extended. The spicules are unequal and dissimilar. They are broad and tubular with a large central cavity. The short right spicule is sickle-shaped ; the longer left spicule is very much more complicated in that the wall is of varying thickness, which gives it a distorted irregular tubular appearance. Its distal truncation is always very oblique.

Female : The principal dimensions of the four adult females are given above. The long, slender oesophagus may be straight, but more often it takes an unusual course, coiling several times around the vagina before joining the intestine. The intestine is moderately large, but the anal pore is extremely small and opens subterminally. The length of the tail is therefore negligible. In young female worms the vagina usually takes a direct posteriad course. In fully gravid females, the uterus usually bends anteriorly and then posteriorly just before reaching the nerve ring (Fig. 2). As the uterus become distended with microfilariae, the oesophagus is pushed outwards toward the periphery and it can then be seen coiling against the body wall.



Chiropterofilaria brevicaudata gen. et. sp.nov

Fig. 1.—Anterior view of young female. Fig. 2.—Anterior view of fully gravid female. Fig. 3.—*En face* view of head. Fig. 4.—Microfilaria. Fig. 5.—Ventral view of male tail. Fig. 6.—Lateral view of male tail. Fig. 7.—Lateral view of female tail.

Microfilaria : The following are measurements of five microfilariae taken at random from two blood smears.

Length	200μ	185μ	195μ	190μ	195μ
Breadth	5μ	6μ	6μ	5μ	6μ
Cephalic space	1·5%	1·6%	1·8%	1·7%	1·6%
Nerve ring	20%	19%	19%	19%	20%
Excretory pore	32·5%	30%	30%	31%	32%
G_1	66·5%	62%	65%	62%	64%
Anal pore	80%	76%	82%	82%	80%

The blood smears were stained with Giemsa. The length, breadth and relative position of the fixed points are shown above. The microfilariae are found in the peripheral blood of both day and night smears. The microfilaria, which is unsheathed, is short, stoutish with ungraceful curves. The nuclear columns are irregular and crowded, and thus the fixed points are not always easily seen.

The present record is believed to be the first record of a nematode, adult or microfilaria, from this host.

Host : *Pteropus hawaiiensis*, Fruit Bat

Location : Peritoneal cavity.

Locality : Fiji (Taveuni and Viti Levu).

Type specimens : Deposited in the Helminthological Collection of the London School of Hygiene and Tropical Medicine.

Relationships

The nearest relative of this new genus is *Lemdana* Seurat, 1917, parasites of birds. These two genera have in common a subterminal cloacal opening. *Chiropterofilaria* gen. nov., however, is easily distinguished from *Lemdana* by the spicules, which are only slightly unequal as compared with the vastly unequal spicules of *Lemdana*, and also by the long narrow oesophagus, which in the female usually makes several coils around the vagina. This peculiar conformation of the oesophagus resembles that in *Dirofilariaeformia sciurorum* Lubimov, 1935 to some extent. In the latter species the vagina coils around the oesophagus, while in our new species, it is the other way about.

MICROFILARIA FIJIENSIS sp. nov.

In the peripheral blood of bats examined, there was also another species of microfilaria. Compared with that of *Microfilaria brevicaudata* described above, it is a longer, and more graceful organism. We propose the name *Microfilaria fijiensis* sp. nov. This unsheathed microfilaria has comparatively sparsely scattered nuclei of varying sizes arranged in two or three irregular rows. A cephalic space is present, while the inner body is only vaguely visible. Measurements of five microfilariae are as follows : Length, 240-292μ with a maximum breadth of 7μ. The relative positions of the fixed points compared with the total length are : cephalic space 2-2·5% ; nerve ring, 18-20% ; excretory pore, 28-30% ; G_1, 60-68% and the anal pore, 72-80%.

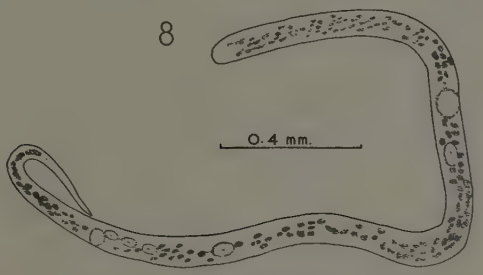


Fig. 8.—*Microfilaria fijiensis* sp. nov.

This is the second microfilaria described from this host. It does not resemble any known to us from bats.

The adult worms were not found. The various developmental stages in the mosquito have been worked out, and will be published later.

ACKNOWLEDGMENTS

We wish to express our gratitude to Professor J. J. C. Buckley for his interest in this study.

Summary

A new genus and species of filarioid worm is described from the peritoneal cavity of fruit bats, *Pteropus hawaiiensis* from Fiji and the name *Chiropterofilaria brevicaudata* n. sp. is given to it. The microfilaria is described. This appears to be the first record of a nematode from this host. The new genus is differentiated from its nearest genus *Lemdana* in that the spicules are only slightly unequal; and in the female worms, the oesophagus usually make several turns around the vagina before joining the intestine. From the same host, a second microfilaria, *Microfilaria fijiensis* n. sp. is described, the adults of which were not found.

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On a New Species of *Euparadistomum* (Dicrocoeliidae Odhner, 1910) from the Fox in Hyderabad (India)

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The present communication deals with an account of a new species of *Euparadistomum* based on material collected on two occasions from the gall bladder of the fox, *Vulpex alopex*. In all, nine specimens were available for study.

The flukes are flattened and pyriform with broadly rounded anterior and posterior ends. The body measures 4·3–5·9 mm. in length with a maximum width of 2·3–3·8 mm. attained at about the equatorial level of the body. The cuticle covering the general body surface is smooth and devoid of spines or papillae. The oral sucker is subterminal with the mouth directed ventrally ; it measures 0·58 by 0·6 to 0·76 by 0·88 mm. The pharynx lying immediately behind oral sucker measures 0·16 by 0·23 to 0·22 by 0·28 mm. and is followed by a slender oesophagus about 0·24 to 0·29 mm. long. The intestinal bifurcation is at the level of the junction of the first and second quarters of the body. The caeca are simple and present a swollen appearance terminating blindly in the subcaudal region of the body. The ventral sucker is located about the centre of the body and is larger than the oral sucker, measuring 0·8 by 0·35 to 1·13 by 1·14 mm.

The excretory pore is subterminal and opens to the outside on the ventral surface. It leads into a Y-shaped bladder which is difficult to observe in gravid specimens as the uterus occupies most of the available space in the postacetabular zone of the body ; but in young adults which have fewer uterine coils the outlines of the bladder are visible and its median stem can be seen reaching into the vicinity of the ovary from where the divided limbs proceed outwards and forwards as shown in Fig. 2.

The testes are symmetrically placed in front of the anterolateral borders of the ventral sucker. They are smooth and rounded in outline, measuring 0·17 by 0·2 to 0·28 by 0·35 mm. The vasa efferentia are short but distinctly visible ; they converge towards the median line to unite into a common vas deferens which immediately enters the cirrus sac, about 0·51 mm. long. Enclosed within the sac are a seminal vesicle, pars prostatica and the terminal cirrus. The latter is often found extruding through the male genital pore which lies in the median line at some distance behind the intestinal bifurcation. The ovary is larger than the testes and measures 0·22 by 0·16 to 0·48 by 0·4 mm. It lies in the median plane or slightly shifted laterally and is partly overlapped by the ventral sucker. The oviduct runs backwards from the ovary and is joined by the duct of the elongated sac-like receptaculum seminis lying behind the ovary. A Laurer's canal is present. The vitellaria are follicular and lie close to the lateral margins of the body forming two isolated groups on either side. Anteriorly they extend to the level of the front borders of the testes, whilst posteriorly they reach into the hind quarter of the body.

The two vitelline ducts from the respective groups of vitellaria on each side unite to form a transverse duct which in turn meets with its fellow from the opposite side to form a short median vitelline duct. The latter opens into the oviduct near the ootype. The Mehlis gland is poorly developed. The uterus, at first descending from the ootype forms several complex coils filling in the postacetabular zone of the body, then it ascends as a median duct into the preacetabular zone where again it is thrown into a complex network of coils extending to the level of the hind border of the oral sucker. Finally the metraterm emerges as a narrow median duct opening anteriorly by the side of the male genital pore. Buckley and Yeh (1958) have successfully elucidated in *E. heischi* the course of the uterus in its entire extent and it appears that in essential respects the same course is followed by the uterus in other species of the genus. The eggs measure 32–50μ long by 20–25μ wide ; they are undergoing segmentation at the time of oviposition ; this is evident from their contents in the uterine loops lying close to the female genital pore.

Discussion : The genus *Euparadistomum* Tubangui, 1931, comprises six species : *E. varani* Tubangui, 1931 ; *E. cerivoulae* Gogate, 1939 ; *E. pipistrelli* (Sandgroud, 1937) Travassos, 1944 ; *E. zonuri* (Malan, 1939) Travassos, 1944 ; *E. paraense* (Jansen, 1941) Travassos, 1944 ; *E. upupai* (Chatterji, 1952) Buckley and Yeh, 1958 ; and *E. heischi* Buckley and Yeh, 1958. The history of the genus and its present composition has been discussed fully by

Euparadistomum buckleyi n.sp.

Fig. 1.—Adult worm, ventral view.

Buckley and Yeh in an earlier issue of this Journal. The author is in complete agreement with their views in regard to the validity of the genus *Euparadistomum* Tubangui, which was also recognized earlier by Travassos (1944) but later disputed by Chatterji (1952). Chatterji's argument for considering *Euparadistomum* as a synonym of *Platynotrema* Nicoll, 1914, is based on the assumption that the pre-acetabular extension of uterine coils is not a distinguishing feature of generic value. The importance of this character can not be minimized since its value in the systematics of Digenetic trematodes is a recognized fact. Ben Dawes (1946) uses this character even in grouping and differentiating some of the families. Buckley and Yeh (1958) are justified in creating the subfamily Euparadistominae on the basis of this important character which brings together under it the genera *Euparadistomum* Tubangui, 1931 and *Stromitrema* Skrjabin and Evranova, 1944.

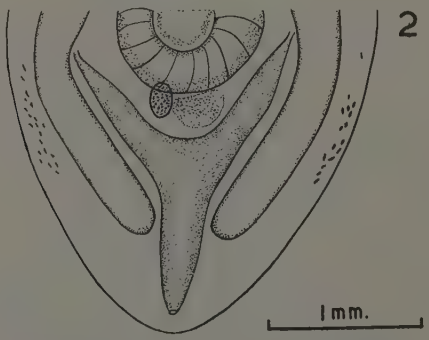

Fig. 2.—Posterior half of adult worm, to show excretory bladder.

The parasite described above resembles *Euparadistomum paraense* (Jansen, 1941) Travassos, 1944, parasitic in the Philander Oppossum, in the general disposition of the gonads and the extent of the vitellaria, but is readily distinguishable from it by the shape of the body. *E. paraense* is strikingly spherical, whereas the new species has a pyriform body with rounded extremities. The species is further differentiated owing to the presence of a comparatively small oral sucker. A closer comparison of *E. heischi*, described in an earlier issue of this Journal, with the new species is desirable since both occur in the gall bladder of carnivores. The most striking

difference is concerned with the size of the testes which assume huge proportions in *E. heischi* being considerably larger than the ventral sucker and the ovary. The suckers are small and subequal in *E. heischi*, whereas in *E. buckleyi* they are large and unequal, the ventral sucker being larger than the oral sucker. The intestinal caeca of *H. heischi* are very slender whilst those of the new species are swollen and extend more posteriorly towards the caudal end. The two species also differ in the shape and various measurements of the body. The new species differs markedly from the other known species from which it can be differentiated with the help of the key given below. It is therefore concluded that owing to its distinguishing features the parasite described herein is new to Science. It is proposed to name it *Euparadistomum buckleyi* n.sp. after Professor J. J. C. Buckley.

Host : *Vulpex alopex*

Habitat : Gall Bladder

Locality : Hyderabad (India)

Type specimens will be deposited in the Helminthological collection of the Department of Parasitology, London School of Hygiene and Tropical Medicine.

Key to the species of *Euparadistomum*

	Genital pore anterior to intestinal bifurcation ...	1
	Genital pore posterior to intestinal bifurcation ...	2
1.	Ventral sucker distinctly anterior to middle of body	*E. zonuri*
	Ventral sucker mostly posterior to middle of body	*E. cerivoulae*
2.	Oral sucker larger than ventral sucker	*E. varani*
	Suckers equal or subequal	3
3.	Ventral sucker larger than oral sucker	5
3.	Testes larger than ventral sucker	*E. heischi*
	Testes smaller than ventral sucker	4
4.	Ovary smooth, mostly overlapped by ventral sucker ; parasites of bats	*E. pipistrelli*
	Ovary lobed, not overlapped by ventral sucker ; parasites of birds	*E. upupai*
5.	Body spherical ; parasites of Marsupials ...	...*E. paraense*
	Body pyriform ; parasites of Carnivores ...	... *E. buckleyi*

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On a New Species of *Stephanofilaria* Causing Dermatitis of Buffaloes' Ears in Hyderabad (Andhra Pradesh) India

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In December, 1957, Dr. Zaheer Ahmad, Veterinary-Assistant Surgeon, Baswada, handed over to the writer for specific determination a few specimens of *Stephanofilaria* which had been collected by him from ear-sores of buffaloes in Baswada (Nizamabad). Since on examination the material was found to consist only of females, it was not possible to identify the species. On consultation of relevant literature, however, it was noted that ear-sore infection associated with *Stephanofilaria* had been recorded by Gopalkrishnan in 1949 in Assam and later referred to by Menon (1952) in connexion with the treatment of "Contagious Ottorrhoea" in buffaloes in Travancore. Since the worm was doubtfully assigned by veterinarians in India to *Stephanofilaria assamensis* Pande, 1935, the writer considered it advisable to make a detailed study of the parasite in order to determine its systematic position. With this object ample material consisting of both males and females was acquired by the writer. The investigation has resulted in the discovery of a new species which is to be named *Stephanofilaria zaheeri* n. sp. in recognition of the first material placed at the writer's disposal.

Material and Methods

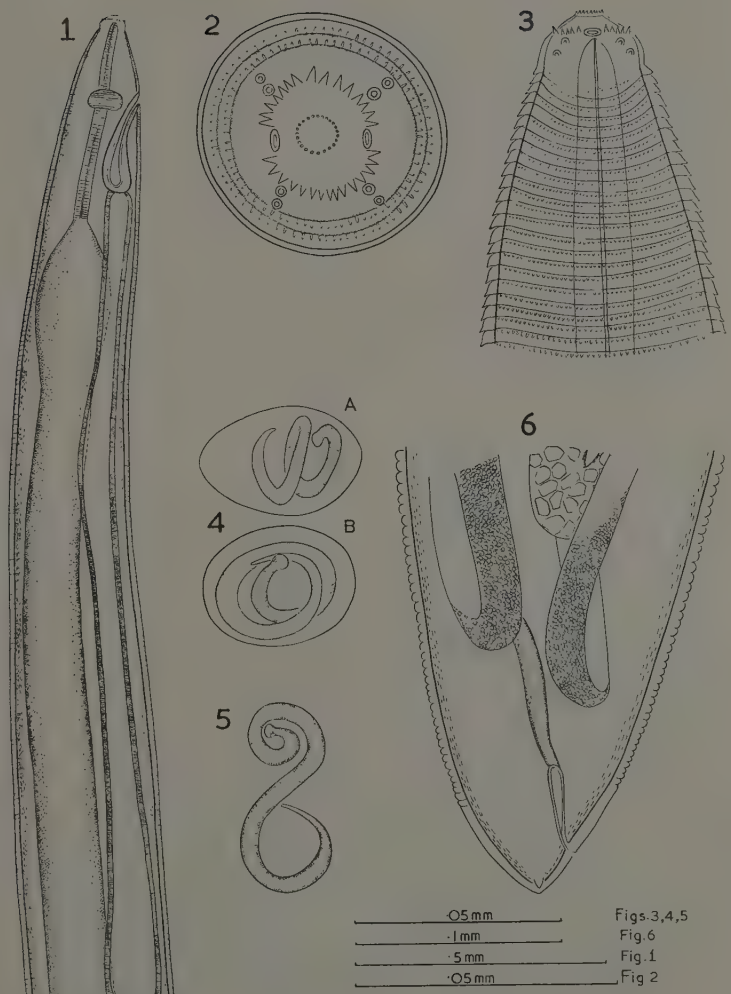
The material which formed the basis of the present study was collected by the writer in Hyderabad during the months of February and March, 1958. The infection among the buffaloes appears to be fairly common, since every third or fourth animal examined at one of the abattoirs in the city was found harbouring the parasites.

In the affected ears of the buffaloes the internal skin was abnormally thickened and covered with papules and encrustations. In advanced stages of the infection the inner surface of the ear showed red patches due to lesions caused by gravid females whose anterior extremities were protruding to the exterior, possibly for the discharge of their progeny. For the extraction of the parasites the ears were chopped off at the abattoir and brought to the laboratory where the worms were collected by the following method : The affected portion of the ear was cut out in a large Petri dish containing normal saline and then with the help of a scalpel the internal skin was carefully peeled off from the ear cartilage. The tissue thus removed was teased out with needles under a binocular microscope. After a little practice entire female worms could be removed with ease. Not much difficulty was encountered in the collection of the small thin male worms, since a good number of them escaped into the saline as the affected tissue was being teased out. The material was fixed in hot 70% alcohol containing 5% glycerine and finally examined in pure glycerine.

Description of *Stephanofilaria zaheeri* n. sp.

The worms are hair-like and slender bodied the females being thicker and two to three times longer than the males. In both sexes the body attains its maximum thickness in its posterior third whilst in front of the middle it tapers gradually towards the head end. Eight males and sixteen females were measured and it was found that the former varied from 3·0 to 4·3 mm. in length by 0·1 to 0·12 mm. in maximum thickness and the females 10·1 to 13·6 mm. by 0·15 to 0·2 mm. respectively. The cuticle is striated and posterior to the striae are found rows of small spines which have been observed in all the species of the genus except *S. stilesi* Chitwood, 1934. The lateral fields are not very prominent, being indicated by only slight interruptions in the transverse striae which actually pass over the fields at the anterior end as illustrated in Fig. 3. Lateral alae are lacking, a feature in which the new parasite resembles *S. dedoesi* and *S. kaeli*.

The head is somewhat dome-shaped with a terminal circular ridge surrounding the mouth. From the ridge projecting forwards are a series of small cuticular spines, about 23–24 in number. A second series of larger cephalic spines is located at some distance posterior to the circumoral ridge, but unlike the ring of spines encircling the mouth this series of cephalic spines is interrupted



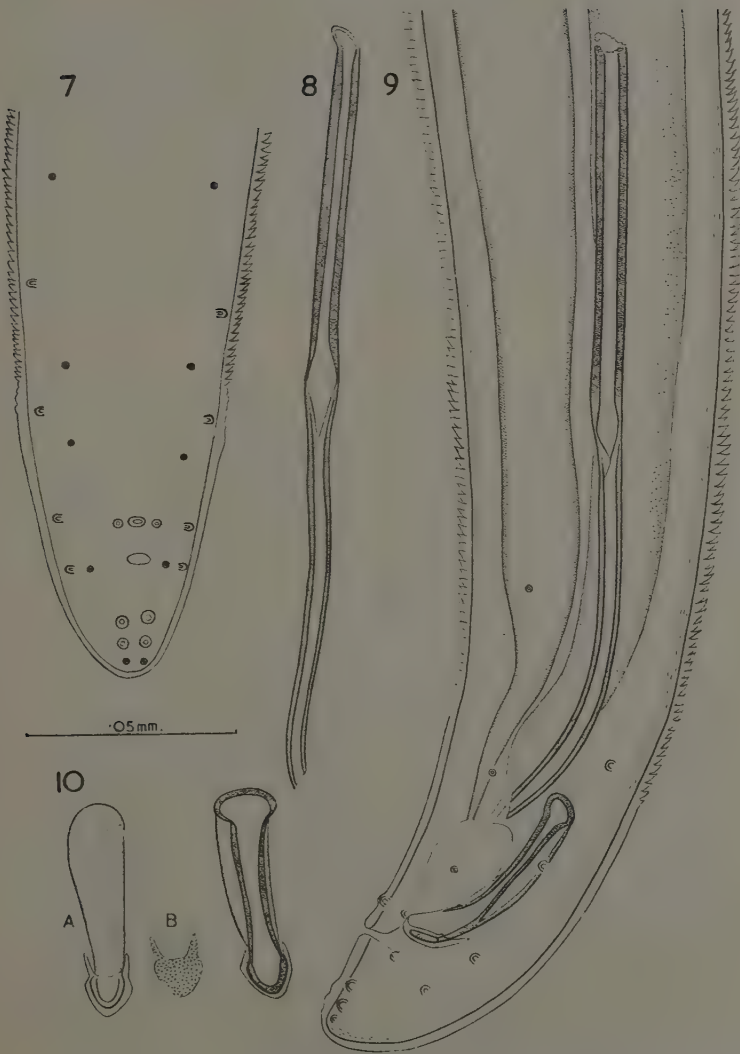
Stephanofilaria zaheeri n.sp.

Fig. 1.—Anterior extremity, female, lateral view. Fig. 2.—Head, female, end on view. Fig. 3.—Head end, female, lateral view. Figs. 4 and 4B. -Eggs. Fig. 5.—Larva, teased out of an egg. Fig. 6. -Tail end, female, lateral view.

laterally by the massive amphids. In addition to the amphids the head bears 4 pairs of submedian cephalic papillae as shown in Figs. 2 and 3. They are arranged in two circles, an inner and an outer each comprising 4 papillae. In order to display the two groups of closely approximated papillae in an end-on view, it is necessary while mounting the amputated head to apply some pressure on the cover glass from above to spread out the cephalic margins immediately posterior to the cephalic spines.

The mouth opens into a shallow vestibule leading into a slender oesophagus which measured 0·15–0·2 mm. in length in the male and 0·19–0·24 mm. in the female. The nerve-ring encircles the oesophagus anterior to its middle and lies 0·06–0·08 mm. from the anterior end in the male and 0·07–0·09 mm. in the female. The intestine presents a distinctly swollen appearance near its junction with the oesophagus.

Male.—The testis extends in front into the anterior quarter of the body where it terminates in a reflexed tip. All three regions of the male duct, a slightly elongated seminal vesicle crowded with minute spermatozoa, the vas deferens, and the terminal ejaculatory duct can easily be differentiated in specimens stained with Nile blue. The tail is short and has a bluntly rounded tip. Caudal alae are lacking as in the other known species of the genus *Stephanofilaria*. The caudal papillae are sessile and can be grouped into (1) postanal papillae comprising three pairs, (2) adanals, two pairs, (3) precloacals, one pair and one median papilla, and (4) preanals, 8 pairs (including adanals). The postanal papillae are located close to the mid-ventral line towards the caudal end. Of these, the two pairs more anteriorly situated are distinctly larger in size as compared with the minute hind-most pair lying close to the tip of the tail. The adanal papillae found on either side of the cloaca can be differentiated into a subventral pair close to the cloacal aperture and a more widely separated and larger lateral pair lying close to the margins of the body. Of the three precloacal papillae situated close together in the same plane in front of the cloacal opening, the median papilla is larger than the other two lying one on either side of it. The remaining six pairs of preanal papillae may be further differentiated into three pairs of small subventrals and three pairs of laterals, the two groups having an alternate arrangement as shown in Figs. 7 and 9. The spicules and accessory piece have been studied in detail in the present worm. As in the previously described species the spicules are unequal in length. The left spicule is tubular and consists of almost equal



Stephanofilaria zaheeri n.sp.

Fig. 7.—Tail, male, ventral view. Fig. 8.—Spicules and accessory piece, ventral view. Fig. 9.—Tail, male, lateral view. Fig. 10A.—Right spicule and accessory piece, dorsal view. Fig. 10B.—Accessory piece, dorsal view, showing pitted markings.

proximal and distal portions, the junction between the two being marked by a slight expansion and thinning of the walls of the spicule. The right spicule is short and stout ; it has a trough-shaped body narrowing distally to end in a spoonhead-like structure with strongly cuticularised margins. On measuring spicules in seven male specimens it was found that the length of the left spicule varied from 0·16–0·22 mm. and that of the right 0·04–0·05 mm. The accessory piece measuring 0·01–0·015 mm. is shaped to accommodate the distal end of the right spicule and has two anteriorly directed lateral projections (prongs) usually found closely applied to the sides of the spicules as shown in Figs. 9 and 10. The surface of the accessory piece presents pitted markings which are discernible only under high magnification.

Female.—The posterior extremity of the body is conical with its anal aperture lying 0·02–0·025 mm. from the tip of the tail. Though the anus is distinct, its passage into the rectum is obliterated. The vulva lies in the oesophageal region at about the level of the nerve-ring and is 0·1–0·12 mm. from the head end. The vagina is in the form of a pyriform sac, about 0·1 mm. long and leads into a tubular ovejector measuring approximately 0·83 mm. in length. The latter is connected at its posterior end to the two uteri which run in a parallel course through the length of the body towards the caudal extremity where each terminates in a slightly expanded receptaculum seminis. The ovarian tubules form closely packed coils extending into the vicinity of the rectum, whilst anteriorly they are connected by a short and narrow oviduct to their respective receptacula seminis. The eggs have thin shells which as they pass into the ovejector and vagina appear like loose sacs containing coiled embryos. The structure of the embryo can be studied to advantage after teasing it out of the egg membrane. It consists of a pinhead-like anterior end, a cylindrical body and a pointed tail ; the cuticle bear fine striations along the entire length. On the anterior end of some embryos faint indications of lateral cuticular ridges, one on either side, were discernible under high magnification. The fully developed eggs found in the ovejector and vagina measured 0·036–0·039 by 0·023–0·029 mm. and the contained embryos 0·085–0·121 mm. in length.

Discussion

In 1933, Ihle and Ihle-Landenberg established the genus *Stephanofilaria* with *S. dedoesi* as genotype for worms causing

"Cascado"—a peculiar skin infection in cattle in Dutch East Indies. Subsequently in 1934 from the same area "Cascado" infections due to *Stephanofilaria* were recorded in goats by Bubberman and Kraneveld, and the latter in 1935 reported localized dermatitis of the ears in buffaloes as being due to *S. dedoesi*. In 1934, Chitwood in the United States described a second species *S. stilesi*, causing generalized skin infections in cattle. A third species *S. assamensis* causing humpsore in cattle in Assam (India) was added by Pande in 1936. Buckley (1937) described another new species, *S. kaeli*, from lesions localized in the legs of cattle in the Malay Peninsula. The present study has resulted in the discovery of a fifth species causing ear-sore in buffaloes in Hyderabad, India.

Comparison of the species of *Stephanofilaria*

Principal body measurements of the five species are given in Table I in which are also recorded anatomical features serving to differentiate them from one another. The measurements show that *S. zaheeri* is characterized by having the largest sized females among the species described so far. With regard to anatomical features it may be pointed that it is not possible for one to make close comparisons of the species, since information as to certain structural details is incomplete in some of them, such as for example, the exact number of cephalic spines on the head, the presence or absence of the anal aperture in the female, and the number and arrangement of the caudal papillae in the male. However, from what we know of the structure the different species can be differentiated as follows : *S. stilesi* is unique in possessing a group of only 4 or 5 cephalic spines asymmetrically arranged, whilst the other 4 species have cephalic spines arranged in a series interrupted by the massive amphids. Judging from the figures given by various authors it is clear that *S. zaheeri* has the maximum number of spines, 28–30. The presence or absence of lateral alae divides the known species into two groups ; these are present in *S. stilesi* and *S. assamensis*, whereas they are absent in *S. dedoesi*, *S. kaeli* and *S. zaheeri*. Another variable character is the anus ; it is present in *S. stilesi*, *S. kaeli* and *S. zaheeri*, whilst it is indistinct in *S. dedoesi* and *S. assamensis*. The caudal papillae in the male which vary in number and arrangement afford one of the most reliable characters for the determination of species. The largest number of papillae has been observed by Buckley (1937) in *S. kaeli* which possesses 3 pairs of postanals, 6–7 pairs of subventrals, 7–8 pairs of laterals, and in the precloacal position there is a

TABLE I (Measurements in millimetres)

	S. dedoesi	*S. stilesi*	*S. kaeli*	*S. assamensis*	*S. zaheeri*
Female					
Length	6·1–8·5	5·64–5·8	6·9–9·4	7·0–9·5	10·1–13·6
Breadth	0·156–0·172	0·1–0·117	0·15–0·16	0·19–0·208	0·15–0·205
Vagina from anterior end	0·049–0·057	0·078–0·09	0·062–0·098	0·075–0·09	0·095–0·12
Anus	indistinct	present	present	indistinct	present
Male					
Length	2·3–3·2	3–3·5	2·6–3·65	3–4·5	3–4·3
Breadth	0·07–0·09	0·04–0·05	0·08–0·1	0·108–0·126	0·1–0·123
Left spicule	0·226–0·23	0·276	0·19–0·23	0·15–0·18	0·16–0·22
Tail length	0·022–0·032	0·018	0·025–0·035	0·025–0·03	0·026–0·03
Postanal ventral papillae	2 pairs	2–3 pairs	3 pairs	2 pairs	3 pairs
Preanal papillae	—	6 pairs	13–15 pairs	—	8 pairs

pair of papillae and a median unpaired papilla. Chitwood (1934) describes in *S. stilesi* 7 pairs of subventral preanal papillae including an adanal pair, and 2 (?3) pairs of postanals. A median precloacal papilla though figured by him is not mentioned in the text. In the new species *S. zaheeri* both the groups of preanals, the subventrals and laterals are represented, a feature in which it shows resemblance to *S. kaèli*. But as compared with the latter *S. zaheeri* possesses fewer subventral and lateral papillae, there being 4 pairs of each group including an adanal pair. The position of the median precloacal papilla varies in the two species ; in *S. kaeli* it is located, midway between the anus and the precloacal pair, whilst it lies directly between the latter in the new species. The postanal papillae in the two species correspond in number and arrangement. In the remaining two species *S. dedoesi* and *S. assamensis* the only papillae described are two pairs of postanals. As regards measurements it may be stated that most of the species, besides differing in overall dimensions, show differences in the distance of the vulva from the anterior end and also in the length of the left spicule. It is also noteworthy that *S. dedoesi* and *S. stilesi* cause generalized skin infections of the host animal, whereas the other three species have become established in particular foci ; *S. assamensis* is associated with hump-sore in cattle, *S. kaeli* with lesions in the legs of cattle, and *S. zaheeri* is confined to the ears of buffalo causing ear-sore. In view of the results presented in this paper it seems quite probably that the ear infections of buffaloes with *Stephanofilaria* in Dutch East Indies are not due to the species *S. dedoesi* as hitherto believed by veterinarians.

A close comparison of *S. assamensis* and *S. zaheeri* n. sp. seems to be necessary, as both the species occur within the same geographical range (India); in Assam for example skin infections associated with *Stephanofilaria* in cattle and buffaloes have in fact been met with in the same locality though in each kind of host different parts of the body are affected. The female of *S. zaheeri* is readily distinguishable from that of *S. assamensis* by its large size as well as by striking differences in various other measurements. An important character which serves to differentiate *S. zaheeri* female from that of *S. assamensis* is the presence in it of a distinct anal aperture which has not been observed in the latter. Lateral alae stated to be present in *S. assamensis* are entirely lacking in the new species. The males of the two species, though similar in size, differ in the length of the left spicule as can be seen in Table I. The caudal papillae in the male also differ in number in the two species ; the only papillae

observed in *S. assamensis*, as noted above, are two pairs of postanals, whereas the new worm possesses an additional small postanal pair at the tip of the tail and as many as 3 precloacals and 8 pairs of preanals including 2 adanal pairs. The male tails in the two species while they are of the same length they seem to differ in shape due to the difference in width of the anus. The male tail of *S. zaheeri* appears thicker and shorter than that of *S. assamensis*. Mature larvae of *S. assamensis* measure 60 to 100μ long as recorded by Sen, Sinha, Chowdhury and Ray (1956) who studied the larvae from preparations made from the scrapings from the hump-sore of cattle. It is noteworthy that larvae within the egg membranes in *S. zaheeri* measured 80 to 120μ long. It is also significant as pointed out elsewhere that the two species not only show host specificity but they have also become adapted to different habitats in the host body.

In view of the distinguishing features discussed above *S. zaheeri* from ear-sores in buffaloes in Hyderabad is considered to be new to science.

Host : Buffalo

Habitat : Skin of the ear

Locality : Hyderabad (India)

Type specimens of the new species described above will be deposited in the Helminthological collection of the Department of Parasitology, London School of Hygiene and Tropical Medicine.

Key to the species of *Stephanofilaria*

1. Cephalic spines 4 or 5 and asymmetrical ; mail tail less than 0·02 mm. long ... ... *S. stilesi*
   Cephalic spines numerous and symmetrical ; male tail longer than 0·02 mm. long 2
2. Female 10·0 to 13·6 mm. long ... ... *S. zaheeri*
   Female less than 10·0 mm. in length 3
3. Female with distinct anus ; male with numerous preanal papillae ... ... *S. kaeli*
   Female without distinct anus ; male without preanal papillae 4
4. Left spicule over 0·2 mm. long ; sexes slender ... *S. dedoesi*
   Left spicule less than 0·2 mm. long ; sexes thicker ... *S. assamensis*

The taxonomic position of the genus *Stephanofilaria* remains for consideration. Ihle and Ihle-Landenberg (1933) in erecting the genus assigned it to the subfamily Setariinae Yorke and Maplestone, 1926, and the family Filariidae Cobbold, 1864. Subsequently Wehr (1935) proposed for its reception a new family Stephanofilariidae. Skrjabin and Schikhobalowa (1945) and Lopez-Neyra (1956) did not recognize the family Stephanofilariidae, whilst the former authors proposed a new subfamily Stephanofilariinae to accommodate the genera *Stephanofilaria* Ihle and Ihle-Landenberg, 1933 and *Icosiella* Seurat, 1917. On the other hand Chabaud and Choquet (1953) and Anderson (1958) consider the family Stephanofilariidae Wehr as valid and suggest certain modifications with regard to its composition. The writer is of the opinion that the status of the family Stephanofilariidae and the affinities of the genus *Stephanofilaria* cannot be determined until the details of the morphology of its larva and its mode of transmission are known.

Acknowledgments

The writer wishes to thank the authorities of the British Council for the generous award of a travel grant which made it possible for the writer to complete this work at the London School of Hygiene and Tropical Medicine. Thanks must also be given to Professor J. J. C. Buckley for providing facilities and for the keen interest shown by him in this study.

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On *Trichochenia mucronata* n.sp. and a New Subfamily Trichocheniinae (Trichostrongylidae Leiper, 1912)

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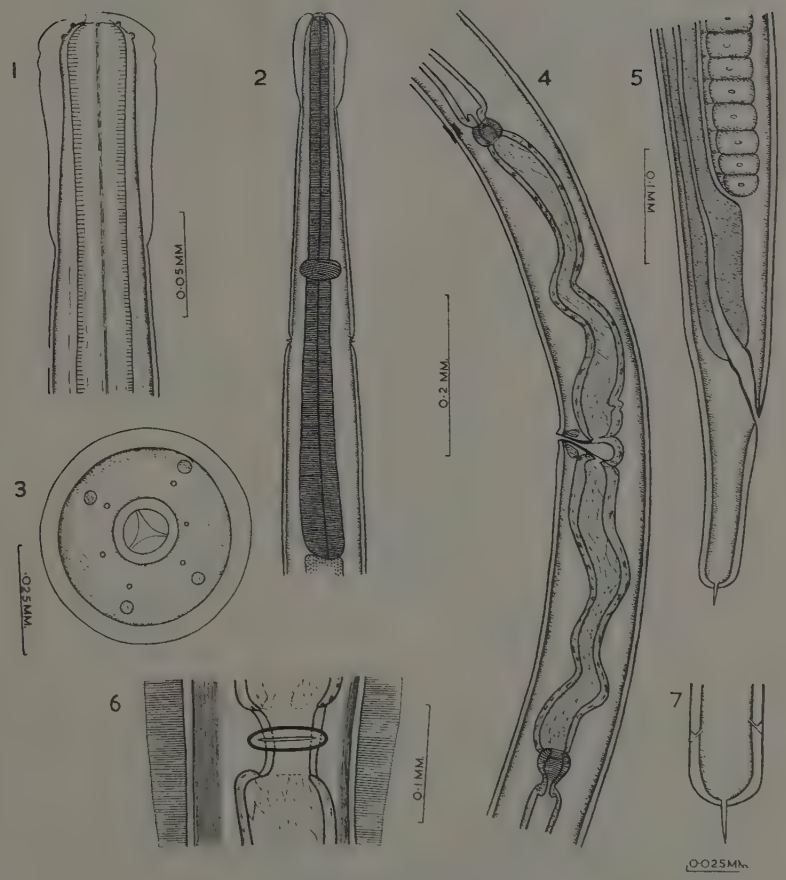
Travassos (1937) in his monograph on Trichostrongylidae Leiper, 1912, deals with Trichostrongyles belonging to 91 genera under 13 subfamilies of which 4 are new. He places *Molineus* Cameron, 1923, along with 33 other genera in the type subfamily Trichostrongylinae Leiper, 1908. Subsequently Skrjabin and Schulz (1937) erected the subfamily Molineinae with *Molineus* as type. Later Skrjabin and Schikhobalova (1934) dealt with 79 genera of worms alloted to 15 subfamilies including Molineinie under Trichostrongylidae Leiper from which they removed the subfamilies Heligmosominae Travassos, 1914, and Ollulinae Hall, 1916. These authors in amending the definition of Molineinae gave a key for differentiating its constituent genera, *Molineus*, Cameron, 1923, *Delicata* Travassos, 1935, and *Shattukius* Sandground, 1938. Under this subfamily another new genus *Angulocirrus* with two species was established by Biocca and Le Roux (1957) for worms found in the African Anteaters, *Orycteropus afer* and *Manis temmincki*. Recently (1958) from *Manis pentadactyla aurita* in China, Kou described three species of a new genus *Trichochenia* also assigned to the subfamily Molineinae. The present communication deals with one more new species of *Trichochenia* from a Pangolin in India.

Trichochenia mucronata n.sp.

In September, 1956, large numbers of male and female specimens of this parasite were collected by the writer from the intestine of a Pangolin, *Manis pentadactyla*, which had died in captivity in the animal-house of the Zoology Department, College of Science, Osmania University.

The worms are filiform, reddish in colour with the body coiled like a cork-screw. To obtain accurate length measurements the worms had to be carefully stretched out immediately after fixation in glycerine alcohol. The sexes do not differ markedly in size, the males measuring 12·5–14 mm. in length by 0·09–0·15 mm. in maximum width and the females 13·5–17·5 mm. by 0·12–0·17 mm. respectively. The body tapers anteriorly in the oesophageal region and the head end is set off by a prominent cephalic inflation of the cuticle. The inflation is smooth in the live condition but becomes crenated in poorly preserved specimens. Both sexes are characterized by the presence of well developed lateral alae which extend through-out the length of the body, becoming indistinct only in the oesophageal region and the tail. The cuticle in the anterior region of the body is finely striated transversely but posteriorly the striae are restricted to the lateral alae and the general body surface shows close set fine longitudinal lines. In addition to these the cuticle bears widely separated prominent longitudinal ridges, a feature common to species belonging to many Trichostrongylid genera. The head is broadly rounded and is without lips ; it bears cephalic papillae arranged in two circles, an outer circle consisting of 4 large submedian papillae and an inner circle of 4 minute papillae corresponding in position to the large papillae. The amphids are faintly visible and have corresponding minute papillae-like projections located in the inner circle of papillae. There are also present a pair of cervical papillae posterior to the level of the nerve-ring, 0·38–0·39 mm. from the head end in the male and 0·44–0·45 mm. in the female. The excretory pore lies immediately anterior to the level of the cervical papillae. The mouth which is surrounded by a cuticular ring leads into a cylindrical oesophagus 0·43–0·56 mm. long in the male and 0·48–0·64 mm. in the female.

Male : The single testis stretches in front into the vicinity of the oesophagus where it ends in a reflexed tip. The spicules are equal and similar in shape, measuring 0·164–0·188 mm. in length. Each spicule has its cephalic end sharply marked off, whilst its body is composed of a short proximal portion and a long and bifurcated distal portion consisting of a main shaft ending in a hooked tip and a prominent lateral process. An accessory piece is present, measuring 0·097–0·113 mm. in length. The bursa consists of two main lateral lobes and a small dorsal lobe. Its inner surface is marked with small spinules which form a characteristic pattern as shown in Fig. 8. A pair of prebursal papillae are also present. The ventral rays of the bursa are long and parallel, the ventro-ventral being shorter



Trichochenia mucronata n.sp.

Fig. 1.—Head end, lateral view. 2.—Anterior extremity, female, dorsal view showing cervical papillae, oesophagus and nerve-ring. Fig. 3. End-on view of head. Fig. 4. -Region of ovejectors, lateral view, showing vulva, vagina and ovejectors. Fig. 5. Posterior extremity, female, lateral view. Fig. 6.—Region of vulva, ventral view, showing vulva, fine longitudinal lines on the body surface, and lateral alae bearing transverse striae. Fig. 7. Caudal end, female, ventral view showing phasmids and caudal mucro.

than the latero-ventral. The antero-lateral runs parallel with the latero-ventral ray and is shorter than the other two lateral rays. The latter run close together and are widely divergent from the antero-lateral ray. The externo-dorsal ray which arises from the base of the dorsal ray is long and of the same length as the postero-lateral ray. The short dorsal ray is divided distally for slightly over one-third of its length and forms a wide fork, each branch being tridigitate. An accessory membrane is present which is supported by a pair of rays and bears two spines projecting ventrally.

Female : The tail of the female is roughly cylindrical with a broadly rounded tip having a terminal mucro. It varies in length from 0·11–0·15 mm. A pair of phasmids is present close to the tip of the tail as shown in Fig. 7. The vulva is situated in the posterior quarter of the body, 2·7–3·2 mm. from the tip of the tail. It leads into a transverse vagina from which the paired ovejectors run in the opposite directions. Each ovejector as figured consists of 3 parts, namely, an elongated sac-like ejector, a globular sphincter and a funnel shaped infundibulum joined to the uterus. A pair of narrow oviducts connect the uteri with the respective ovaries which are long, ribbon-shaped structures. The posterior ovary at first extends backwards for a short distance close to the rectum where it is reflexed to run forwards. As a result of this the two gonads run parallel in the prevulvar region. The tip of the anterior ovary projecting considerably beyond that of the other ovary extends into the vicinity of the oesophagus. The eggs are thin shelled measuring 0·054–0·061 mm. by 0·024–0·031 mm.

Discussion : Kou (1958) described three species of *Trichochenia* all from the same host *Manis pentadactyla aurita*. A close comparison of his species shows that *mi* was probably dealing with two species *T. cantonensis* and *T. papillosa*. Both as regards principal measurements and morphology *T. manisa* does not differ sufficiently from the type species *T. cantonensis* and hence may be regarded as its synonym. In size as well as anatomical features the parasite described above differs markedly from the two species of *Trichochenia* found in the same host in China. In the male of the new species the ventral rays of the bursa are unequal in length whilst these in the males of the two earlier species described from China are equal. In the new worm the lateral process lying alongside the main shaft of the spicule is shorter than that found in the spicules of known species. The female of the species under study is characterised by having a caudal mucro which is shorter than the width at the tail

Meyer (1896) described from the Pangolin in Ceylon a bursate nematode which he designated *"Strongylus costatus"*. The structure of this worm is very imperfectly known and its systematic position has remained undetermined so far. Though it resembles *Angulocirrus* in having hooked spicules in the male, it is excluded from this genus by the presence of lateral alae in both sexes. In this feature it resembles *Trichochenia* to which it is definitely referable. Its specific

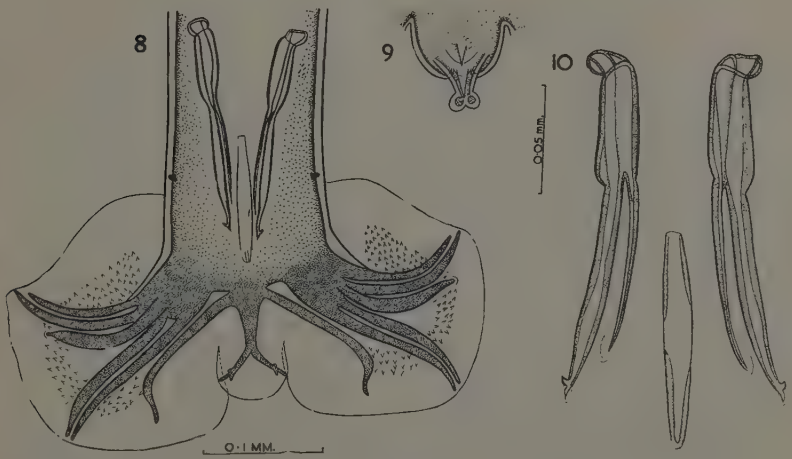


Fig. 8.—Male bursa, dorsal view. Fig. 9.—Male, genital cone and accessory membrane, ventral view. Fig. 10.—Spicules and accessory piece, ventral view.

identity, however, can not be established since the structural details of the bursa and spicules are not known. It may, however be pointed out that the newly described species differs in measurements from those recorded for *"Strongylus costatus"*. The female tail is roughly three anal diameters in length in the new species whilst it is roughly 4 anal diameters in *Strongylus costatus* which has also a comparatively longer caudal spike.

In view of the distinguishing features exhibited the worms described above are considered to be a new species of *Trichochenia*. In view of the fact that the female of the new species possesses a

very small caudal spike it is proposed to name it *Trichochenia mucronata* n.sp.

Host : *Manis pentadactyla* (in captivity)

Habitat : Intestine

Locality : Hyderabad (India)

Systematic position of *Trichochenia*

Kou in his discussion on the affinities of his new genus *Trichochenia* does not mention *Angulocirrus*, presumably being unaware of its existence. Since these two genera are very closely allied, it is necessary to compare them in detail. In possessing a cephalic inflation, in the general disposition of the gonads, in the shape of the tail in the female, and in the structure of the accessory membrane in the male bursa, the two genera resemble each other very closely. They however differ in the following features : Lateral alae are present in both sexes in *Trichochenia* whilst they are lacking in the species of *Angulocirrus*. Unlike the males of *Trichochenia* those of *Angulocirrus* are characterized by having markedly dissimilar spicules. Prebursal papillae are found in all species of *Trichochenia*, but these have not so far been observed in the two known species of *Angulocirrus*. The ventral rays as well as the medio and posterolateral rays diverge distally in *Angulocirrus* while these two pairs of rays in *Trichochenia* run parallel in close proximity along their entire length. The anterolateral ray differs markedly in its position in the two genera ; it remains isolated between the ventrals and the other laterals in *Angulocirrus*, whereas it is closely applied to the latero-ventral ray in *Trichochenia*. The externodorsal ray is considerably longer than the dorsal ray in *Trichochenia*, whilst these two rays are roughly of the same length in *Angulocirrus*.

A detailed study of the structure of the recent genera *Angulocirrus* and *Trichochenia* and their close relationship to *Maciella* Travassos, 1935 and *Delicata* Travassos, 1935 shows that it is justifiable to bring together under a common subfamily these 4 closely allied genera all of which are exclusively parasitic in the Edentates. Their allotment to Cooperiinae and Molineinae is evidently a matter of convenience only. All these genera are characterized by the presence in the male bursa of an accessory membrane supported by a pair of rays. The genus *Molineus* which has well defined characters and which is

composed of a large number of species is conspicuous in the absence of the accessory membrane in any of its known species. There are also striking resemblances in the structure of the spicules of species belonging to the 4 genera under discussion. It is noteworthy that not a single species of *Molineus* has so far been found parasitic in the Edentates, and none of the 4 genera under discussion are represented in hosts other than the Edentates. There are thus sound arguments in favour of the inclusion of the four genera in a common subfamily. It is, therefore, proposed to erect a new subfamily Trichocheniinae with *Trichochenia* as type.

Definition of the subfamily *Trichocheniinae*

Trichostrongylidae : Head with a cuticular cephalic inflation ; cervical papillae usually present ; female with vulva in the posterior region of the body and having a tail conical or cylindrical with a terminal spike ; male bursa provided with an accessory membrane supported by two digitiform rays ; anterolateral ray more or less isolated from the other lateral rays or closely applied to the ventroventral ray. Parasites of Edentates. Type genus : *Trichochenia* Kou, 1958.

Key to the genera of *Trichocheniinae*

	Rays supporting accessory membrane of bursa arising independently	1
	Rays supporting accessory membrane of bursa arising from a common stem	2
1.	Cephalic vesicle asymmetrical ; female tail conical	*Maciella*
	Cephalic vesicle symmetrical ; female tail usually cylindrical	*Delicata*
2.	Lateral alae present ; anterolateral ray closely applied to ventroventral ray	*Trichochenia*
	Lateral alae absent ; anterolateral ray isolated from other laterals and ventrals	*Angulocirrus*

Acknowledgment

Thanks are due to Professor J. J. C. Buckley for some useful suggestions and for providing facilities for work.

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On an Interesting New Nematode *Velariocephalus trilokiae* gen. et sp. nov. from an Indian Frog and a New Subfamily Velariocephalinae (Cosmocercidae)

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During a visit to Kakinada, Andhra Pradesh (India) in April, 1956, the writer examined thirty specimens of the frog *Rana cyanophlyctis* and found that every one of them was heavily infected with an interesting nematode in the rectum. Large numbers of males and females of this parasite were collected and fixed in 5% formalin containing 10% glycerine. Specimens thus fixed and preserved could easily be dissected for preparing mounts of reproductive organs for detailed study. Before being dissected the preserved worms were at first washed in tapwater and then placed in 70% glycerine alcohol which was allowed to evaporate until the worms were in almost pure glycerine. At this stage a trace of Nile Blue in absolute alcohol was added to the glycerine and the worms were left in it overnight. By this means the reproductive organs were stained lightly before they were dissected out from the body of the worm under the binocular. The gonads were finally mounted in glycerine jelly in which they could be properly displayed. Entire specimens were stained and mounted by the same method.

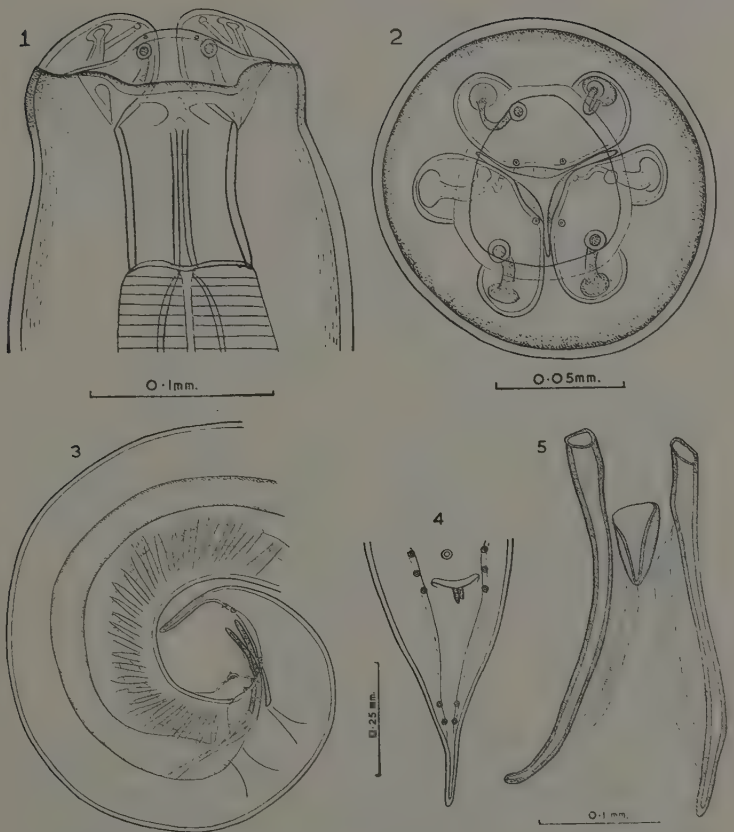
Morphology

The body in both sexes is of uniform thickness narrowing only at the anterior and posterior ends. The head is knob-like and separated from the rest of the body by a slight constriction. It bears a circular cephalic velarium or collar surrounding the base of the lips. The cuticle carries fine transverse striae which can be seen only under high magnification. The excretory system communicates with a median vesicle which is elongate oval in outline. The vesicle opens by a short narrow duct at the excretory pore which lies considerably behind the level of the nerve-ring, which encircles the oesophagus near its anterior end. The head bears three transparent lips of which one is dorsal and the other two subventral in position. The cephalic papillae are very well developed

and borne on long and distinct peduncles. They are arranged in two circles, an outer and an inner, each having four papillae. Of the four papillae in the outer circle the two subdorsals are borne by the dorsal lip and the two subventrals by the subventral lips. The paired amphids lying in the outer circle, one between the subdorsal and subventral papilla on either side, are carried by the subventral lips. They can be easily differentiated from the cephalic papillae since they appear as circular openings placed at the top of hollow stalks. The minute papillae of the inner circle, also four in number, correspond in position with the large papillae of the outer circle. The very fine stalks of the inner papillae spring from the main peduncles of the large papillae. The amphids are also represented in the inner circle by a corresponding pair of minute pores. A pair of very fine ducts connect these pores with the hollow stalks of the amphids. The head is thus characterized by the presence of highly developed cephalic papillae which are prominently displayed owing to the transparent nature of the lips.

The mouth which is surrounded by the lips leads into a strongly chitinized vestibule. A cuticularized framework supporting the cephalic velarium springs from the anterior end of the vestibule as illustrated in Fig. 1. The oesophagus terminates in a spherical valvular bulb preceded by a prebulbar enlargement. The oesophago-intestinal valves are well developed and the anterior end of the intestine is expanded, frequently forming a cup-like investment round the base of the oesophageal bulb.

Male.—The males are only slightly smaller and thinner than the females and measure 6·9–9·6 mm. in length and 0·38–0·42 mm. in greatest width. The vestibule is 0·065–0·08 mm. long by 0·053–0·062 mm. wide and the oesophagus including the bulb varies in length from 0·93 mm. to 1·27 mm. The nerve-ring and the excretory pore lie at a distance of 0·33 and 0·93 mm. from the head end respectively. The single gonad in fully developed males forms a complete loop extending forward to the front end of the intestine, whilst posteriorly the tip of the testis extends into the region of the rectum. The different parts of the gonad, the testis, seminal vesicle and the vas deferens are well defined and sharply marked from each other. The testis is the longest of the three, extending along the entire length of intestine to its anterior end where it turns and runs backwards to join the seminal vesicle at about the middle of the body. Starting from the tip of the testis the terminal cell with its clear cytoplasm and a large nucleus stands out prominently,

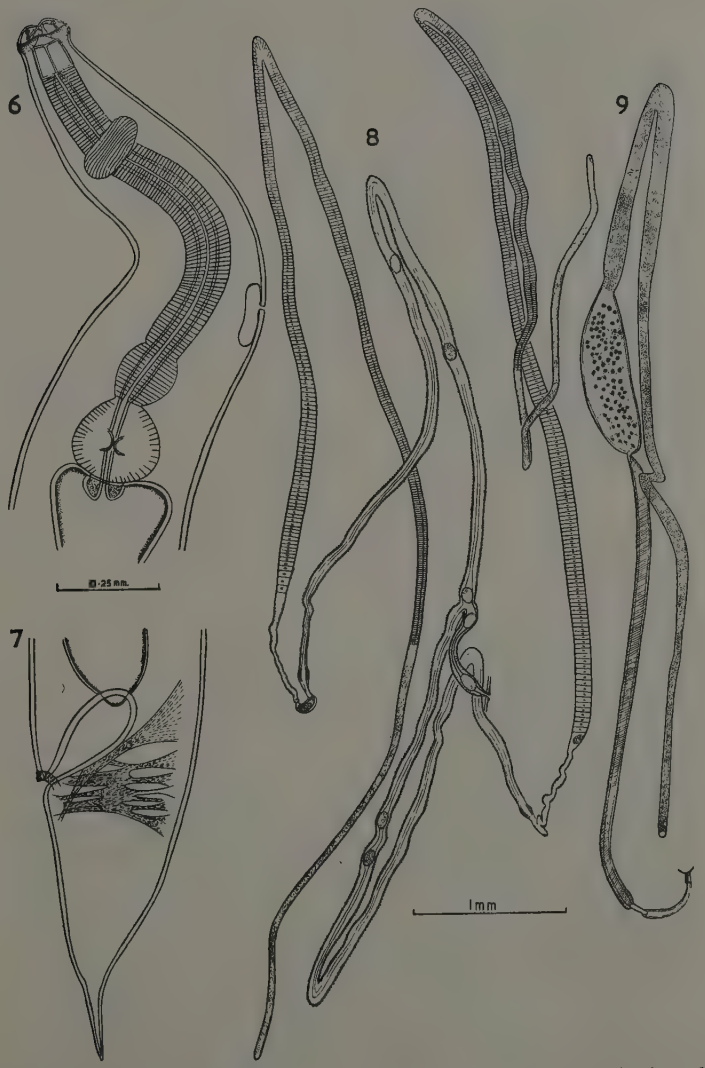


Velariocephalus trilokiae gen. et sp.nov. 1.—Head end, male, dorsal view. 2.—Head, male, end-on view. 3.—Male tail, lateral view. 4.—Male tail, ventral view. 5.—Spicules and accessory piece, ventral view.

then follows the germinal zone of the testis in which the spermatogonia are found undergoing rapid division. This is followed by the region of growth in which the spermatocytes are seen in various stages of development, ultimately being set free at the end of the testis. The seminal vesicle is a large pyriform sac sharply marked off from the testis in front and the vas deferens behind. It is crowded with minute spermatozoa and the maturing spermatocytes. The vas deferens runs backwards from the seminal vesicle to the cloaca and is divided into a long anterior and a short posterior portion the

junction between the two being marked by a sphincter. The hind end of the short portion forms the ejaculatory duct which opens into the cloaca. A pair of small cement glands lies closely applied to the ejaculatory duct near its opening into the cloaca. The spicules are similar and equal, having slightly expanded anterior ends and bluntly pointed tips. They measure 0·25–0·29 mm. in length and are provided with two lateral membranous expansions having a crenated appearance. The accessory piece measuring 0·067–0·09 mm. long is roughly triangular with its lateral margins folded ventrally. The posterior extremity in the male is strongly curved ventrally with the cloacal aperture opening into a pocket-like cavity bounded by a ventral fold of the body wall. Also characteristic of the male tail is the presence of obliquely set precloacal muscle bands, 29 to 30 in number, which extend in the precloacal zone of the body for a distance roughly equal to twice the length of the tail. The latter is cone-shaped with a digitate tip. It measures 0·48–0·5 mm. long and is provided with narrow caudal alae which start a little anterior to the anus and terminate posteriorly in front of the digitate tip of the tail. The caudal papillae are sessile and bear apical spikes. In all there are 5 pairs and a median precloacal papilla. Of these, three pairs are postanal, 2 pairs situated close to the tip of the tail and one pair immediately posterior to the cloacal opening. All the preanal papillae are located in proximity with the cloacal opening, the large precloacal papilla lying at some distance in front of it and the two preanal pairs situated on either side in a line with the first pair of postanals.

Female.—The females do not differ markedly in size from the males, being only slightly longer and thicker than the latter. They measure 8·7 to 10·6 mm. in length and 0·42–0·55 mm. in maximum thickness. The vestibule is 0·075–0·082 mm. long by 0·062–0·065 mm. wide. The oesophagus including the terminal bulb measures 1·1 to 1·27 mm. The tail is conical with its tip prolonged into a pointed process ; it measures 0·58–0·72 mm. in length. The anus opens into a pocket which is more developed than that enclosing the cloacal aperture in the male. A similar structure has been described by Goodey & Cameron (1923) in *Ascaris columnaris* Leidy, 1856. The vulva is situated a little behind the middle of the body and is 3·8–4·6 mm. from the tip of the tail. It is surrounded by prominent lips and leads into an anteriorly directed curved vagina. The two uteri run in the opposite directions and both are reflexed so as to form distinct loops. The descending limb of the anterior uterus runs backwards into the region of posterior uterus to join its receptaculum seminis. This in turn is connected with a sac-like enlargement



Veleriocephalus trilokiae gen. et sp.nov. 6.—Anterior extremity, male, lateral view. 7.—Female tail, lateral view. 8.—Reproductive organs of female. 9.—Reproductive organs of male.

which forms the second flexure in the gonad. It probably functions as an additional chamber of the receptaculum seminis, since it is often found crowded with spermatozoa. The short, narrow oviduct, which runs forwards from this sac, is joined at its opposite end to the ovary. The latter runs as far forwards as the anterior end of the intestine where it is recurved to form the third flexure in the gonad. From here the ovary runs backwards down the length of the body, its tip reaching into the neighbourhood of the rectum. The other gonad has altogether five flexures, the two additional flexures occurring one in the course of the uterus and the other in the course of the ovary as illustrated in Fig. 8. Because of its additional flexure the terminal segment of the ovary in this case proceeds in the anterior direction, whilst for the rest of its course it runs almost parallel with the other ovary. From Fig. 8 it will be seen that the gonad with five flexures has no additional chamber associated with its receptaculum seminis. The eggs are oval in shape measuring 0·13–0·14 mm. long by 0·082–0·09 mm. wide.

Relationships

The anatomical features of this new parasite reveal its affinities with several genera of the family Cosmocercidae Travassos, 1925, though it cannot be assigned to any of them. Its female reproductive organs closely resemble those of *Oxysomatium* as illustrated in *O. giganticum* and described by Olsen (1938). It differs however, from *Oxysomatium* in several important features, such as the structure of the head and the oesophagus, and the character of the male tail. The male *Velariocephalus* in possessing a series of precloacal muscle bands resembles the males of *Cosmocerca* Diesing, 1861 and *Cosmocercella* Steiner, 1924, whilst in the absence of plectanes it is excluded from them and the other genus *Cosmocercoides* Wilkie, 1930, all of which belong to the subfamily Cosmocercinae Railliet, 1916. The worm *Nematoxynema piscicola* (Linstow, 1907) Skryabin and Shikhobalova, 1951, parasitic in an African fish, is closely allied to the new worm from amphibians in India. Their close affinities are revealed in the structure of the highly specialised cephalic papillae and the character of the male tail with the precloacal muscles, and with the somewhat similar arrangement of caudal papillae. Skryabin and Shikhobalova (1951) created the genus *Nematoxynema* and gave the generic definition. Because of the scanty description of the type and also the only species of the genus at present available, it is not possible to make a close comparison of *Nematoxynema* with the new genus *Velariocephalus*.

In the following features, however, the two genera are found to differ markedly from each other. The male *Nematoxynema* has no gubernaculum, whereas in the male of the new parasite it can be readily observed. A distinct cephalic velarium supported by a cuticularized framework surrounds the lips in *Velariocephalus*, whilst in *Nematoxynema* this is only indicated in a rudimentary form by the inwardly projecting processes on the lips called "Spitze" by Linstow. The shape of the male tail also differs in these two parasites. Unlike that of *Nematoxynema* the male tail of the new worm is produced into a digitiform process. In this character and the structure and arrangement of postanal papillae, it is interesting to note that *Lauroia* species parasitic in Armadillos show close resemblance to the newly found parasite though differing from it in many essential features. A median precloacal papilla and caudal alae though slightly developed are present in *Velariocephalus* and not represented in *Nematoxynema*. It is, therefore, concluded that the worm described above is a new species with peculiar anatomical features which justify for its reception the erection of a new genus. The genus is named *Velariocephalus* n.g. on account of the presence of the cephalic velarium. The writer proposes to name the species *Velariocephalus trilokiae* n.sp. after his wife Mrs. Triloki Devi Singh.

Generic diagnosis

Cosmocercidae : Head with lips bearing massive pedunculated papillae ; a circumlabial cephalic velarium supported by cuticularised framework present ; anus and cloacal aperture opening into a pocket ; a vestibule is present with strongly chitinized walls; oesophagus with a terminal valvular bulb preceded by a prebulbar enlargement.

Male.—With precloacal muscle bands and with digitate tip the tail ; spicules equal, accessory piece present ; narrow caudal alae present ; caudal papillae bearing apical spikes ; postanal papillae 3 pairs, preanal papillae two pairs and a large median papilla.

Female.—Vulva immediately postequatorial ; uteri opposed.

Genotype : *Velariocephalus trilokiae* gen. et sp.nov.

Host : *Rana cyanophlyctis.*

Habitat : Rectum.

Locality : Kakinada, Andhra Pradesh (India).

Velariocephalinae n.sf.

With the formation of the new genus *Velariocephalus* the family Cosmocercidae Travassos, 1925, contains two genera showing highly specialized cephalic structures in the form of massive pedunculated papillae and with the tendency to form a distinct or rudimentary cephalic velarium. The males of these two genera are also characterized by the presence of well developed precloacal muscle bands, a feature which reveals their kinship to Cosmocercinae Railliet, 1916. From a detailed study of the new parasite the writer feels it desirable to propose for its reception a new subfamily Velariocephalinae. It it also proposed that the genus *Nematoxynema* on the basis of its close affinities with the new genus be transferred from Amblyonematinae Skryabin and Shikhobalova, 1951, to the new subfamily Velariocephalinae.

Subfamily diagnosis

Cosmocercidae.—With highly developed pedunculated cephalic papillae ; with a distinct or rudimentary cephalic velarium ; males with precloacal muscle bands. Parasites of fishes and amphibians.

Subfamily type.—*Velariocephalus.*

Other genus.—*Nematoxynema* Skryjabin et Shikhobalova, 1951.

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Pages 97 and 98, for *Papillosclerus* read *Papilloslerus*
Page 191, for *Paranomotaenia* read *Anomotaenia*

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